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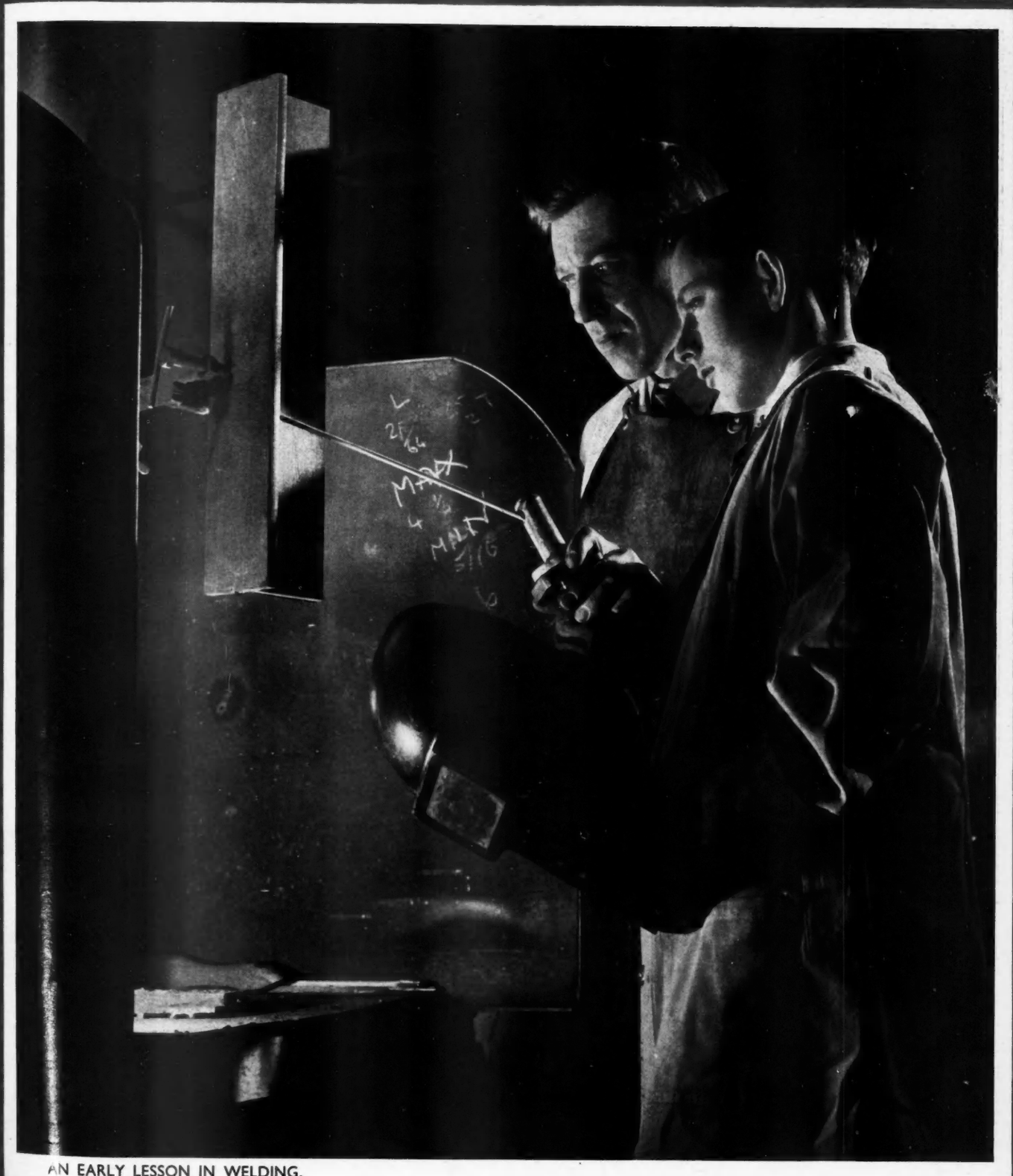

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ELECTRICITY SUPPLY OF THE CITY OF ZÜRICH.

IN common with many other places, the demand for electric power in Zürich in the winter tends to exceed the available supply. This is in some part due to an increasing population but to a larger extent to industrial development. No doubt, as elsewhere, the winter demand exceeds that of the summer and conditions are made more difficult by the fact that the discharge of the Alpine rivers, on which the operation of the power stations depends, is at its lowest during the winter months. At present, the system, which is owned by the municipality, can meet its winter load only by the purchase of bulk power from outside sources; part of this power is imported from abroad. During the winter months, which are taken as extending from October 1 to March 31, the total energy demand of the city is 380 million kWh, but under favourable conditions, the stations owned and operated by the city can supply only 270 million kWh; in a difficult year, this figure may fall to 200 million.

ALBULA POWER STATION.

All the important stations are situated in the Grisons Canton, in a district which lies some 50 miles south of Zürich. The first station to be built utilises the waters of the River Albula which rises in the Rhaetian Alps and joins the Hinter Rhein, a tributary of the Vorder Rhein which flows into Lake Constance. The Hinter Rhein joins the Vorder Rhein at a point some 7 miles west of Chur, or Coire. The station is situated at Sils, a village near the confluence of the Albula with the Hinter Rhein. A river flow of 16 cub. m. per second is available for an average of 200 days a year, but in the winter it may dwindle to 6 to 7 cub. m. per second. The available head is 150 m. and the catchment area extends to 912 sq. km. The station was built between 1906 and 1910 and originally contained eight 300-h.p. units. After 35 years' operation, it was reconstructed, in 1944-45, and modernised; the old sets were replaced by two 16,000-h.p. Francis turbines and the water supply was increased to 22 cub. m. per second. Flow in the winter months, however, is still somewhat less than one-third of this figure.

HEIDSEE POWER STATION.

Output from the Albula station was supplemented by the construction of the Heidsee station in the years 1917 to 1920. This utilises the waters of the Heidbach, a tributary of the Albula River, which it joins near Solis. A sketch map, showing the rivers and the situation of the power stations, is reproduced in Fig. 2, on page 130. This is based on an illustration which appeared in our Swiss contemporary *Wasser und Energiewirtschaft*. The Heidbach rises in the small lake known as the Heidsee which consequently forms a natural reservoir for the power station. The lake is near the small town of Lenzerheide, a holiday and winter-sports centre. The station contains two 6,500-h.p. units and the discharge is led into the feeder tunnel of the Albula station thus increasing the supply to this latter station which is situated lower down the valley. The Heidsee station has an output of 27 million kWh per annum.

BURVAGN DAM.

Soon after the reconstruction of the Albula station, a project was worked out for the utilisation of the water of the Julia river which flows down the Oberhalbstein Valley. This is a well-known holiday district and the valley forms an extensive catchment area. The Julia River joins the Albula some few kilometres above the Heidsee station, as shown in Fig. 2. Work on the project was started in 1945, and the station, which is near the town of Tiefenkastel, has been in operation since July, 1949. The maximum available water supply is 11 cub. m. per second, but in winter it may fall to 2 or 3 cub. m. per second. The yearly output of the station is about 140 million kWh, but of this total only 47 million kWh are produced in the winter months. Of the combined outputs of the Albula and Julia stations, 65 per cent. of the yearly energy is delivered in the summer. Neither of these stations has extensive water storage, the small reservoirs from which they are fed serving only to cover daily fluctuations in demand.

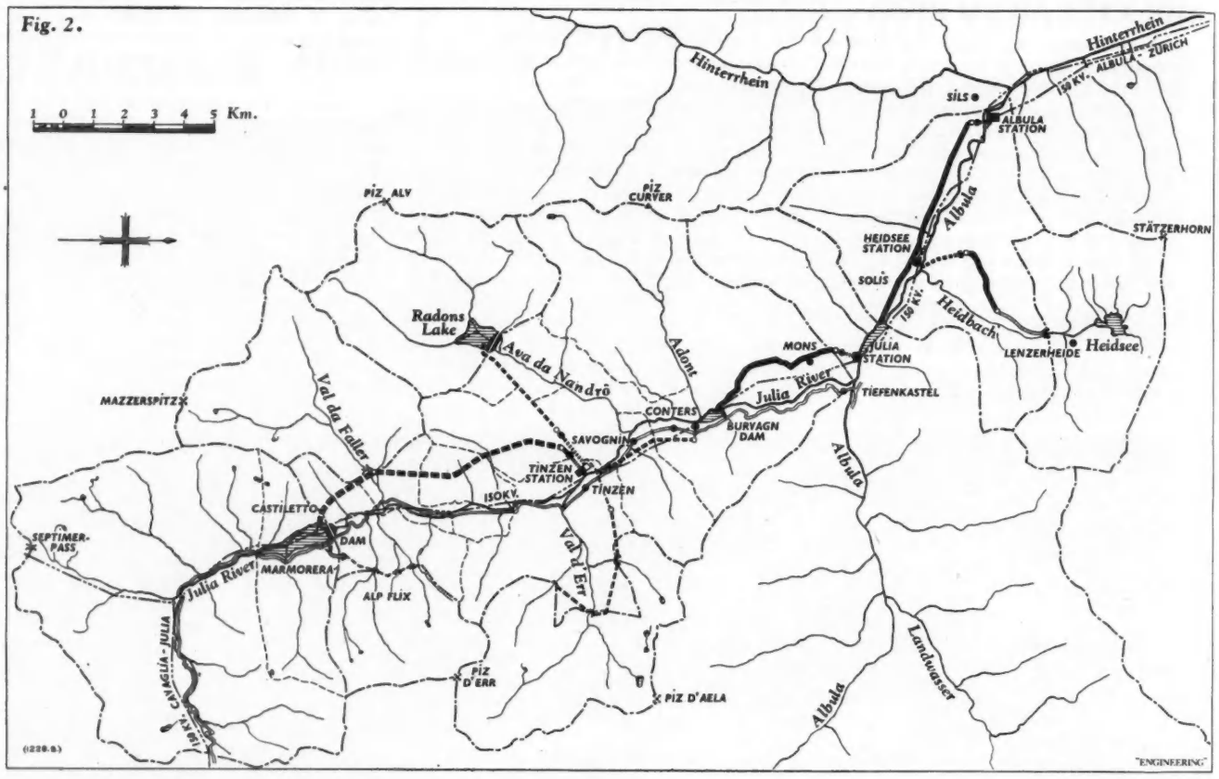
It was originally intended that the Julia station should be in operation in 1948, and the turbines and other equipment were installed in that year, but owing to difficulties encountered in driving the feeder tunnel, the whole project was not completed until 1949. The dam built across the Julia River to form the equalising reservoir is near the village of Burvagn; the position of the dam is shown in Fig. 2. The dam forms a reservoir the surface of which is about 9 m. above the river bed and 1,117 m. above sea level, as indicated in Fig. 3, on page 130, which is a profile showing the reservoir, feeder tunnel and penstock. The reservoir is about 800 m. long and has a capacity of 200,000 cub. m. The dam, a concrete structure embodying about 150 tons of reinforcing steel, is 48 m. long and has a maximum height of 20 m. It is faced with silicious limestone or granite, the total surface treated amounting to about 2,100 sq. m. During its construction the river was diverted to a wooden channel, laid on a concrete base, on the right-hand side of the original bed. The channel was 60 m. long and 7 m. wide, and was sufficiently large to carry 10 cub. m. of water per second.

FIG. 1. UPSTREAM FACE OF BURVAGN DAM.

A general view of the dam, looking downstream, is given in Fig. 1, on this page, and a part longitudinal elevation and part longitudinal section in Fig. 4, on Plate X. Figs 5 to 7, on the same Plate, are cross sections. The dam has three main openings and, at the left-hand side, a chamber which leads to a de-silter situated at the head of the feeder tunnel. Water enters the chamber through a trashrack lying at right-angles to the longitudinal axis of the dam. The rack, the bars of which are set 35 mm. apart, can be distinguished to the left of the main openings in Fig. 1. The dam, as shown in Fig. 4, is bonded into the mountain slope at each end; approximately 7,000 cub. m. of moraine sand and dolomite blocks had to be removed when preparing the foundations. As shown in Figs. 4 to 7, a concrete cut-off wall, 2 m. thick, is provided below the upstream face of the dam. In the centre it extends to the datum level of 1,099, 20 metres below the crest of the dam. The wall steps upward towards the wings of the dam, as shown in Fig. 4. This figure also indicates the points at which piles were driven below the base of this wall. At a

ELECTRICITY SUPPLY OF ZÜRICH.

Fig. 2.

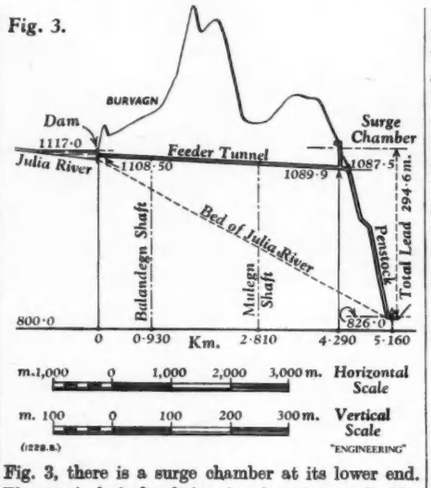


point towards the right-hand end of the dam, sheet piling had to be used; this is shown in Fig. 4. Grouting was carried out at various weak spots, particularly in the neighbourhood of the sheet piling.

The three main openings of the dam are each 4 m. wide. The two on the right are provided with steel gates; that on the left is closed by means of stop-logs. The store for the logs when not in use, and for spares, is at the right-hand end of the dam, as shown in Figs. 4 and 7. The arrangement of the two right-hand openings is shown in Fig. 5. Ground outlets, 2·5 m. by 4 m., are provided to deal with heavy river discharges. They are controlled by sliding steel gates operated by winch gear situated on the crest of the dam. They can be operated either electrically or by hand. As shown in Fig. 5, the ground-water channel through the dam is paved with granite blocks to prevent erosion. The spillway discharges above the cross members of the openings are also controlled by sliding steel gates operated by winches in the same manner as the ground-water gates. The chamber behind the trashrack also contains a sliding steel gate which controls the discharge to the de-silter and so to the feeder tunnel and power station. The de-silter, built in the hillside below the dam, has an internal capacity of about 3,000 cub. m. Normally, the spillways provide sufficient discharge capacity for excess water, but for heavy flows the ground-level gates are opened. The stop-log gate is available to deal with exceptional floods.

The feeder tunnel, starting beyond the lower end of the de-silting chamber, has a total length of 5,133 m. with a fall of 3·8 per cent. During its construction, much difficulty was caused by underground water and loose rubble, and it was these unfavourable conditions which delayed the opening of the station by about a year. It is 2·26 m. in internal diameter and is lined with concrete varying in thickness from 25 to 45 cm. The water velocity in the tunnel is 2·5 m. per second, and, as shown in Fig. 3, there is a surge chamber at its lower end. The vertical shaft of the chamber, 3·5 m. in diameter and 33 m. long, has a cubic capacity of 275 cub. m.; at its upper end, it connects to a second chamber 22 m. long and 5 m. in diameter, and having a cubic capacity of 440 cub. m. Two drift shafts were sunk for the construction of the tunnel, one at Balandegn and the other at Mulegn; their respective lengths were 462 m. and 370 m. Their positions are indicated in Fig. 3. Much fissured rock was encountered during the driving of the tunnel and a considerable amount of grouting was necessary.

Fig. 3.



The penstock is 850 m. long. At its upper end there is a control chamber excavated in the rock. It contains measuring and recording instruments and an automatically-operated butterfly valve. The penstock consists of three sections, respectively 340, 290 and 220 m. long, the corresponding internal diameters being 1·7 m., 1·6 m. and 1·5 m. The pipes were supplied in 10-m. lengths and were welded together on site. A temporary metre-gauge rope-haulage railway was built for conveying the pipe from the point of delivery near the power station site to the surge chamber. The pipes were brought by rail to Tiefenkastel station, and loaded on to lorries for the remainder of the journey. The pipes varied in wall thickness from 8 mm. to 30 mm., and the total weight was about 520 tons. As the penstock does not embody arrangements to allow for expansion, the pipes were immediately encased in concrete after welding up the sections, and the penstock tunnel was filled in, in order to protect the pipes from the sun or changes in air temperature. An average of 3 or 4 pipes of 10 m. length were laid per week. The penstock, which is provided with five inspection manholes, has a fall of 66 per cent.

JULIA POWER STATION.

The power house is situated on the left bank of the Albula River near the reservoir which equalises the daily flow to the Albula Station situated farther down the river. Excavation for the turbine house of the Julia Station was begun in 1946 and by July, 1947, construction had so far advanced that a start could be made with the machinery installation. A view of the turbine house under construction is given in Fig. 14, on page 132, and Figs. 8 and 9, on Plate XI, are two views of the completed station. It contains two vertical Francis turbines built by Messrs. Escher Wyss. They are each rated at 16,000 h.p., but the output varies between 15,950 and 17,500 h.p., owing to the net head fluctuating from 275 to 293 m. The speed is 1,000 r.p.m., and the water consumption at an output of 16,000 h.p. is 5 cub. m. per second.

A cross-section of the turbine room is given in Fig. 13, on page 132, and a cross-section of one of the turbines in Fig. 12, opposite. Fig. 13 shows the incoming penstock connection to the turbine. It is provided with a motor-operated cut-off butterfly valve which may, in emergency, be controlled by hand. Above the outlet to the tail race, there is a

BURVAGN DAM; ZÜRICH ELECTRICITY SUPPLY SYSTEM.

(For Description, see Page 129.)

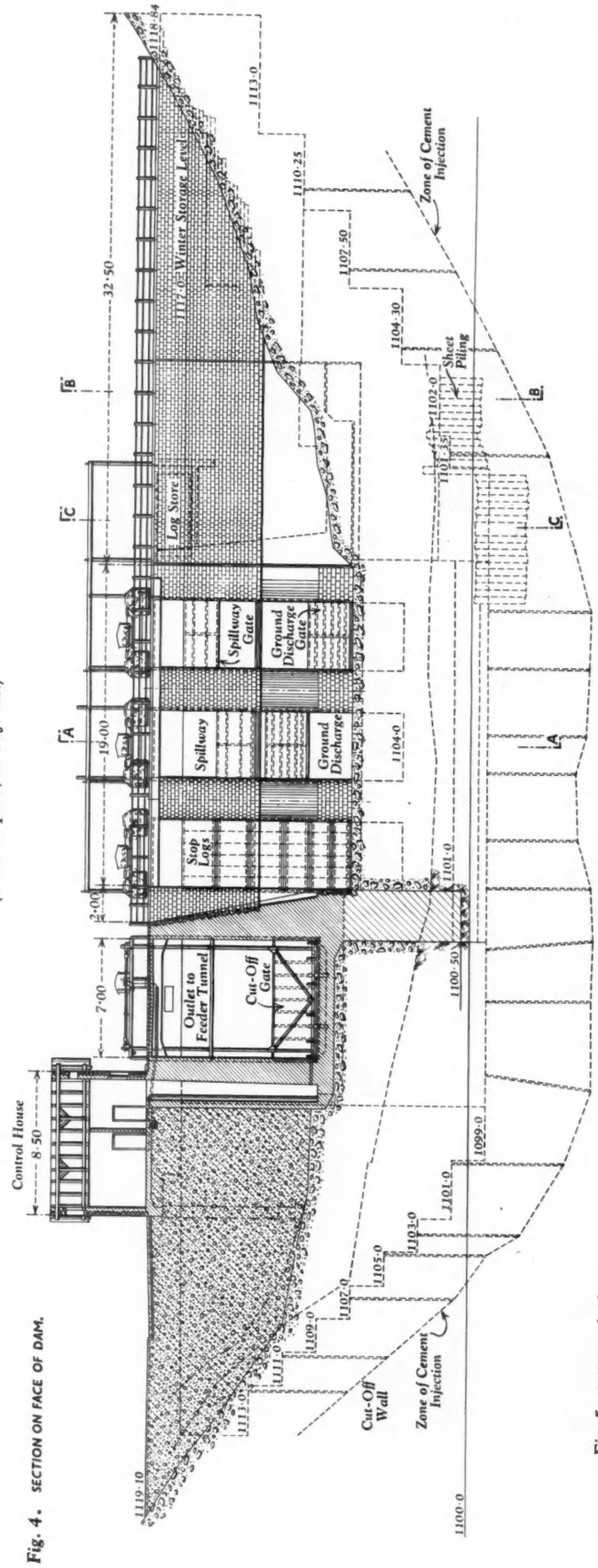


Fig. 4. SECTION ON FACE OF DAM.

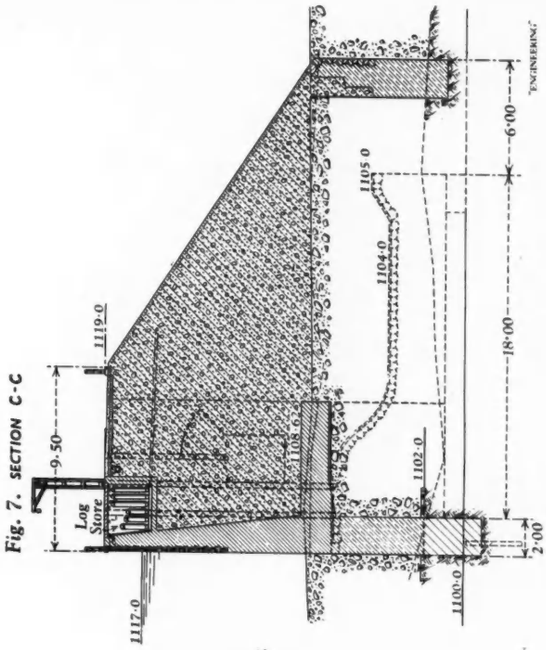


Fig. 7. SECTION C-C

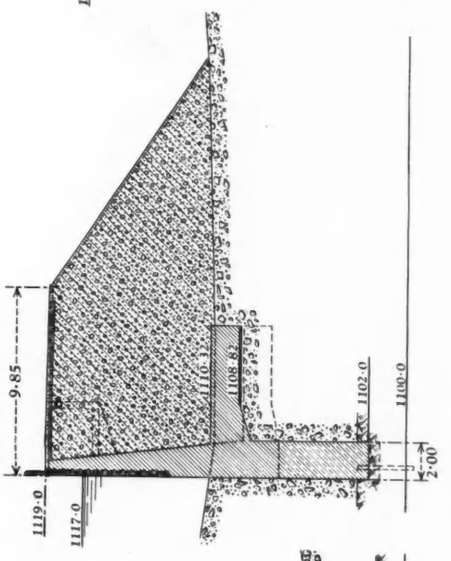


Fig. 6. SECTION B-B

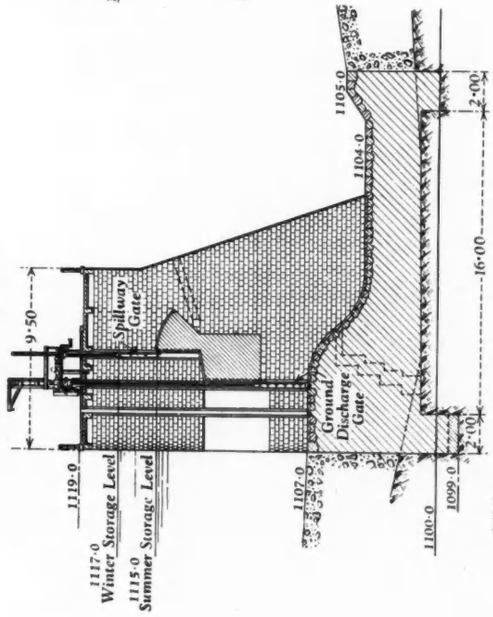


Fig. 5 SECTION A-A

(To face page 130.)

JULIA POWER STATION; ZÜRICH ELECTRICITY SUPPLY SYSTEM.

(*For Description, see Page* 129)

FIG. 8. VIEW OF STATION SHOWING SWITCHYARD.

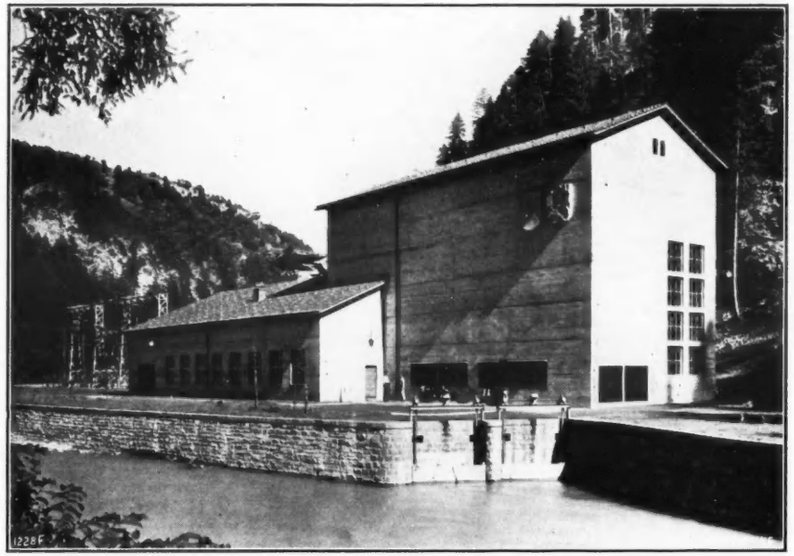


FIG. 9. VIEW OF STATION SHOWING INTAKE FROM RIVER.

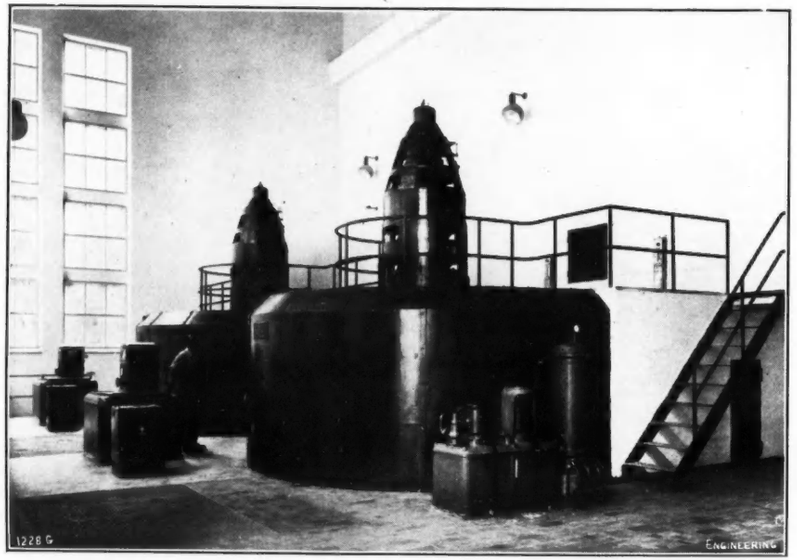


FIG. 10. INTERIOR OF GENERATOR ROOM.

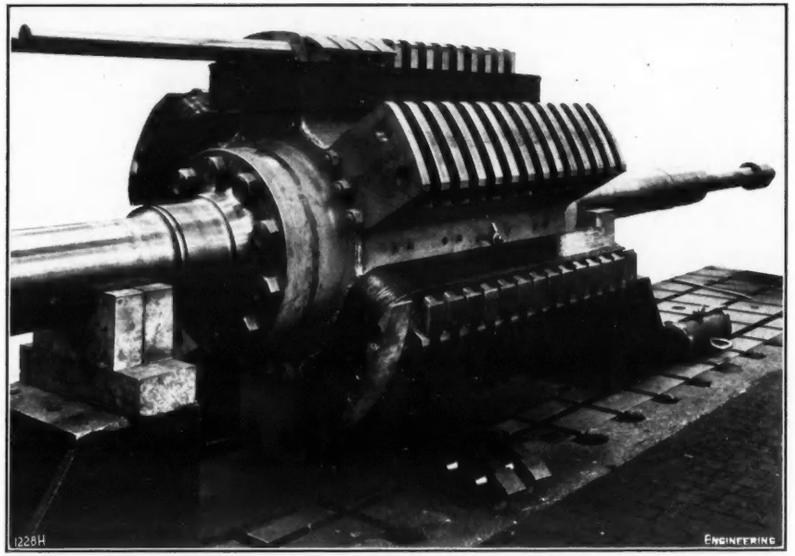


FIG. 11. ALTERNATOR ROTOR FRAME ASSEMBLED.

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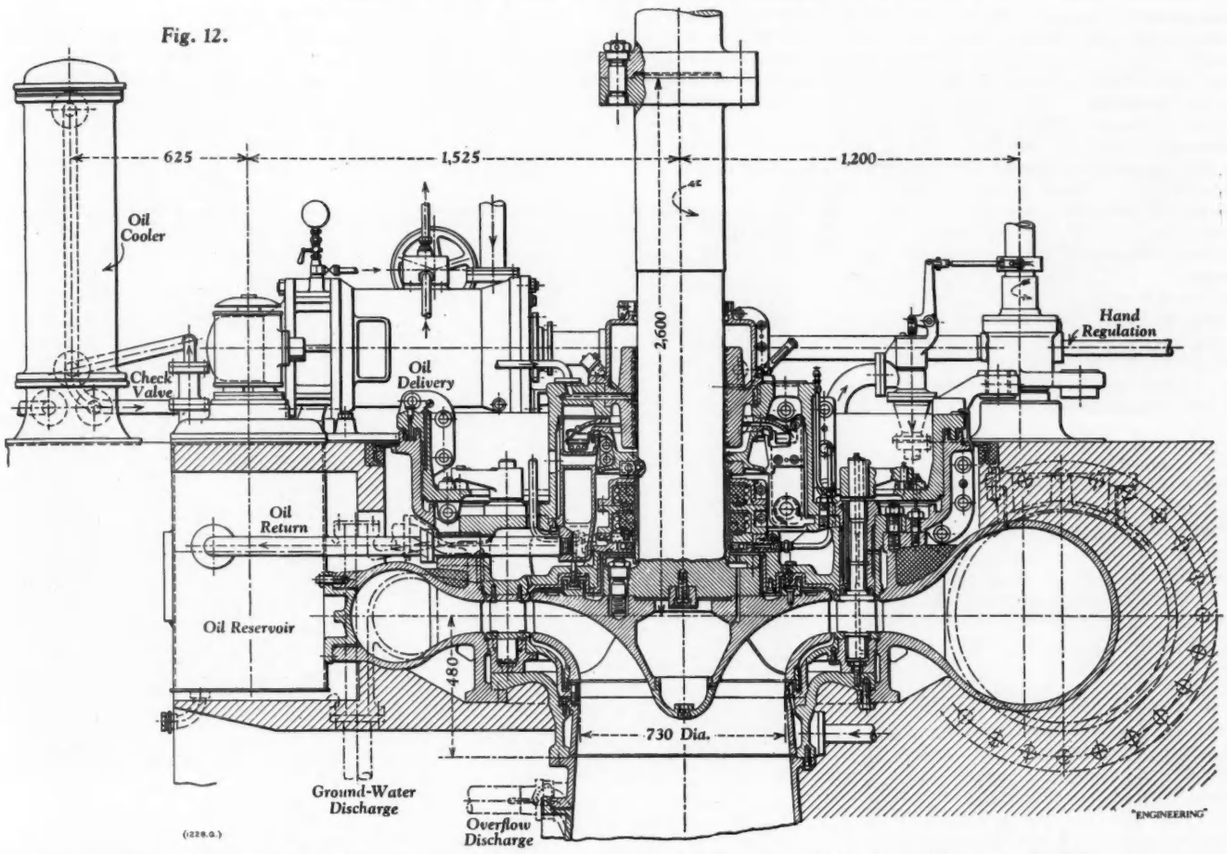
Fig. 12.



room containing hand-operated selector switches, enabling the alternator connections to the switch-gear to be changed when necessary. The room containing the hand gear is separated from the high-tension chamber. The control room for the outdoor switch station is situated in the lower part of the building shown to the left in Fig. 9. The turbine room is provided with a 35-ton overhead travelling crane, this capacity being sufficient to lift the heaviest part of the turbine or alternator. The latter is connected to the 310-mm. diameter turbine shaft by a flange coupling. The turbine runner is 1,050 mm. in diameter.

The Oerlikon generators are rated at 15,000 kVA and supply three-phase current at 6,600 volts. An interior view of the station showing the machines is given in Fig. 10, on Plate XI. They are of the totally-enclosed air-cooled type, the ventilating air, drawn in from outside, being, in the winter, discharged into the interior of the building to warm it. The stator housing is a single iron casting, the stationary armature being built up of laminated steel plates. The winding is of grid construction, with two conductors in each slot. There are six terminals and the neutral point is brought out. The rotors embody a number of special features and the generators are claimed by the makers to be the largest machines, with poles of the salient type, directly coupled to the turbine and running at the high speed of 1,000 r.p.m.; the runaway speed is 1·8 times the normal running speed.

The rotor body is built up of 14 steel star-shaped plates, of which two examples are illustrated in Figs. 15 and 16, on page 133. The one shown in Fig. 15 is an end plate, provided with a facing to which the shaft coupling is bolted, as shown in the assembled view given in Fig. 11, on Plate XI. The plates are held together by through bolts situated at the bases of the salient poles; the bolts being heated before assembly. With the main frame of the rotor built up, as shown in Fig. 17, on page 133, the wound magnet coils are placed in position over the salient poles, as shown in Fig. 11. The pole pieces, which are steel castings, are then inserted between the salient poles and are secured by round bars passing through the pole pieces and to holes at the outer ends of the salient poles. Two of the bars protruding from the assembly are shown in Fig. 11. Finally, wedge-shaped spacers are placed between the pole pieces to prevent any radial movement of the coils under centrifugal force. The spacers, which are so formed that an air-duct channel is provided under the coils, can be seen in the view of the completed rotor given in Fig. 18, on page 133. The arrangement is completed with non-magnetic cup-shaped steel rings at each end of the rotor.

At the runaway speed of 1,750 r.p.m., the peripheral speed of the rotor attains a value of 146·5 m. per second, the centrifugal force on a single pole being 2,000,000 kg. These figures are nearing the limit permissible for the method of securing the pole pieces which is used but, from theoretical considerations, the makers are of opinion that this type of construction could be used for machines running at 1,000 r.p.m. up to a capacity of 48,000 kVA. The machines generate 6,600-volt current at 50 cycles, the rated voltage fluctuation limit being plus or minus 5 per cent. The stator current is 1,315 amperes and the cooling-air supply 20 cub. m. per minute. The maximum short-circuiting moment is 120,000 m.-kg. Distant-reading thermometers are provided, indicating the coil and bearing temperatures at the instrument panel. The exciters, located above the upper bearings of the generators, are rated at 112 kW, the output being 465 amperes at 250 volts. Above each exciter, there is a permanent-magnet generator which supplies current for the guide-vane governing equipment of the turbine. The generator has a capacity of 2·4 kVA, and generates at 110 volts and 100 cycles per second.

The main generators are directly connected to two banks of three single-phase transformers, supplied by Messrs. Brown, Boveri and Company. They are of the outdoor type and are situated in the transformer and switchyard alongside the station, as shown in Fig. 8. A separate view of the transformer is given in Fig. 19, on page 133. The transformer groups, rated at 15,000 kVA, step up the station current to 150 kV. The transformers are oil cooled and the attached tanks are provided with external cooling tubes, as can be seen in the figure. The cooling action of the upward flow of air over the tubes is supplemented by fans in hot weather. The decision to install single-phase transformers was reached owing to the difficulty of transporting heavy plant over the narrow gorge road leading to the station site.

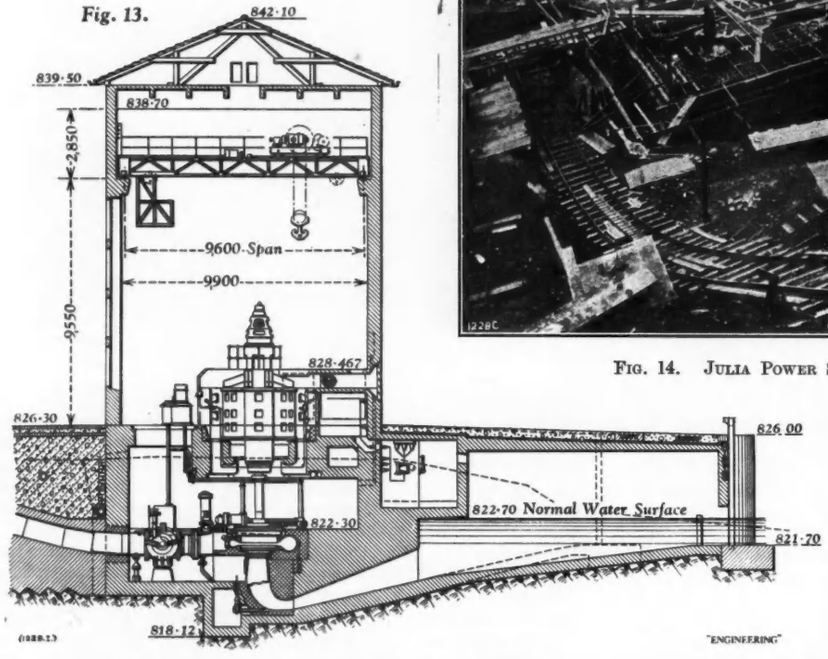
The 150-kV sides of the transformers are connected to low oil-content circuit-breakers situated on the opposite side of the switchyard from the transformers. This gear was supplied by Messrs. Sprecher and Schuh, of Aarau. The circuit-breakers each consist of three independent single-phase units with actuating gear in common. Each unit consists of a vertical column built up of two porcelain sections connected by a metal sleeve. The lower section provides insulation from earth and the upper forms the interrupter chamber. The circuit is broken in an arc-quenching chamber situated in an oil-filled insulating cylinder housed in the upper porcelain section. The arc-quenching chamber is provided with contact fingers at top and bottom and contact is made, or broken, between these sets of contact fingers by a small-diameter contact tube which is moved up or down by the breaker-operating mechanism. The breaker

is tripped by a spring wound up by a motor situated in a weatherproof cabin at ground level; if necessary, the spring may be wound up manually. The spring operates a horizontal shaft which is connected to the contact tubes of each phase by insulating rods.

The control room of the Julia station contains two rapid-acting Brown-Boveri voltage regulators, one for each machine. The equipment also includes differential relays for protection against short circuits between phases, maximum current time-lag relays, maximum voltage relays and over-speed and reverse-load protective gear. The switchboard panels carry all the necessary indicating and recording instruments for the 6·6-kV and 150-kV systems.

In addition to the gear for the main transformer circuits, the switchyard contains breakers controlling outgoing feeders which connect to the Albula station, whence current is transmitted to Zürich. Furthermore, gear is provided for the control of a supplementary feeder line to the city,

Fig. 13.



which transmits current generated in the Brusio power station, which is owned by the Brusio Kraftwerke A.G. This station is situated in the Poschiavo Valley, some 20 miles south of St. Moritz; much of its output is exported to Italy. It should be mentioned here that the City of Zürich has a financial interest in the Maggia power station, which is being built by the Maggia Kraftwerke A.G. The station is situated on the Maggia River, which runs into Lake Maggiore at Locarno. Supply from the station will ultimately be available for transmission to Zürich. At the present time, the energy provided by the Albula and Julia power stations, owned by the Zürich Corporation and situated on the Albula-Julia river system, is equivalent to 312 million kWh per annum. Of this, 65 per cent. is available in the summer and 35 per cent. in the winter. The yearly contribution of the Albula station is 172 million kWh, and that of the Julia station 140 million kWh. It will be remembered that the Albula station receives extra water in the form of the discharge from the Heidsee station, situated on the Heidbach, as shown in Fig. 2.

MARMORERA DAM.

An additional station is now being built farther up the Julia River, which, when completed, will not only increase the proportion of energy available in the winter, but will enable the purchase of power from the Brusio station to be discontinued. The Oberhalbstein district, which forms the catchment area of Julia River, offers possibilities of water storage not available farther down the river and a dam is accordingly being built at Marmorera across the river. This is about 12 miles south of Tiefenkastel. The reservoir which will be formed will have a capacity of about 60 million cub. m. of water. The dam is of the earth-fill type and the magnitude of the work is shown by the fact that it will be the largest dam in Europe in which that form of construction is employed. The reservoir will serve a power station to be built at Tinzen, which is a short distance south of Savognin, and about 7 miles north of the site of the dam. As the discharge from the new station will pass to the Julia and Albula stations, the winter output of these two stations will be increased. The sites of the dam and station are shown in Fig. 2.

A geological survey carried out in 1947 and 1948, in the course of which a large number of borings were made, showed the valley at Marmorera to be the most suitable site for the building of a dam at reasonable capital expenditure. The natural catchment area of the Marmorera Valley is estimated at 89 sq. km. and, by diverting the waters of the Fallerbach and a stream from the Flix Plateau, an additional catchment area of 45·5 sq. km. has been brought in, making a total of 134·5 sq. km. The annual water supply is calculated at 168 million cub. m., of which 138 million, or 82 per cent., are available during the summer and 30 million, 18 per cent. during the winter. The reservoir will enable 60 million cub. m. to be stored during the summer. On the completion of the dam, there will accordingly be 78 million cub. m. (138 less 60) of water available during the summer months and 90 million cub. m. (30 plus 60) during the winter. As all the water will pass to the Julia and Albula stations, the winter output of the former will be increased from the present 47 million kWh to 87 million, giving a yearly output of 180 million kWh, compared with the 140 million which was given earlier. The effect on the Albula station will be to increase the winter output from 63 million kWh to 83 million, and the yearly output from 172 million to 192 million. The Tinzen station will have a yearly output of 156 kWh,

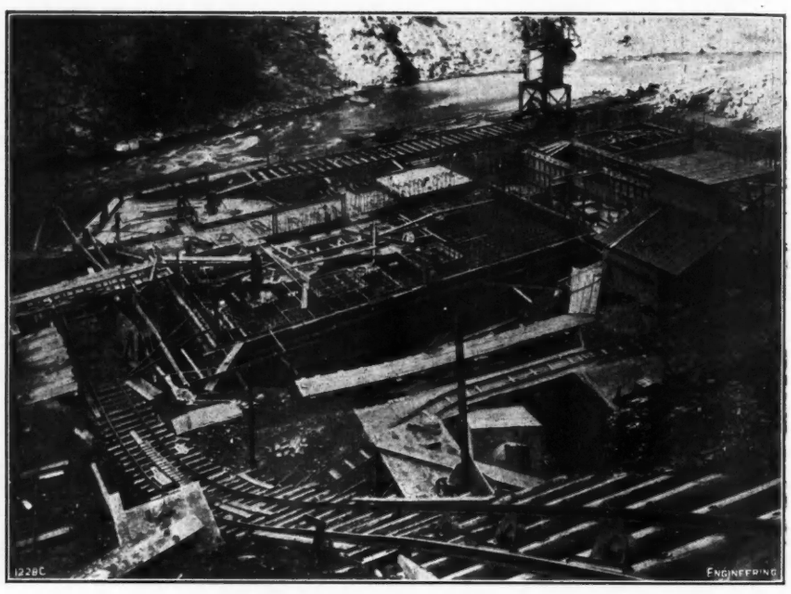


FIG. 14. JULIA POWER STATION UNDER CONSTRUCTION.

so that the output of the four stations will be increased from 339 kWh to 555 kWh per annum, nearly half of which will be available in the winter. The output of the Heidsee station, which forms one of the four, is not affected by the Oberhalbstein scheme.

From a topographical point of view, the Marmorera valley was particularly suitable as the site of a dam, being narrow and of V-shaped cross-section. The dam will have a crest length of 400 m. and a maximum height above the river bed of 70 m. The reservoir which will be formed will be 2·6 km. long with a greatest width of 0·8 km.; the surface area will be 1·4 sq. km. From a geological point of view the conditions, however, were not quite so favourable. Although the ground towards the east flank of the valley is rocky, of metamorphic structure, the flat base of the valley upstream from the dam is formed by alluvial deposits of silt and gravel. Surveys indicated that bonding between the dam and the mountain flanks could be considered safe from the point of view of seepage, and it was decided that the most suitable type of construction would be a compacted-earth dam with a central zone of impervious material, the outer slopes being formed of semi-pervious material with rock facing on the upstream side and a toe of broken rock for the downstream face.

In 1949, before construction was begun, a tunnel was driven into the west flank of the mountain at elevation 1612, some 12 m. above the base of the dam. Test borings were made from this tunnel, and, as a result of the conditions disclosed, it was decided to construct a concrete cut-off diaphragm on the axis of the dam and carried down to bedrock. This concrete wall, which has a depth of 30 m. was completed in 1950. In order to select suitable material for the various zones of the dam, borings were made in the neighbourhood and

ELECTRICITY SUPPLY OF ZÜRICH.

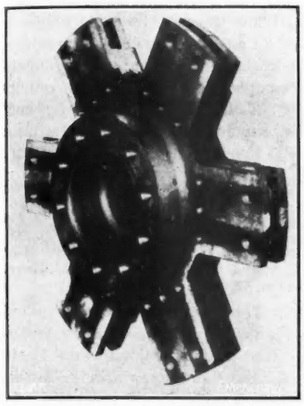


FIG. 15. ROTOR END PLATE.

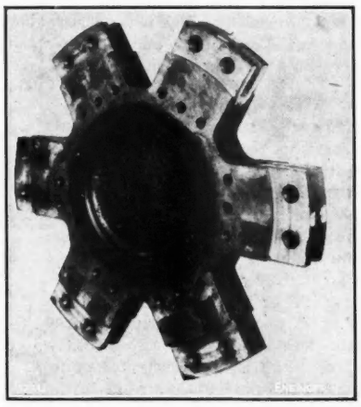


FIG. 16. ROTOR STAR PLATE.

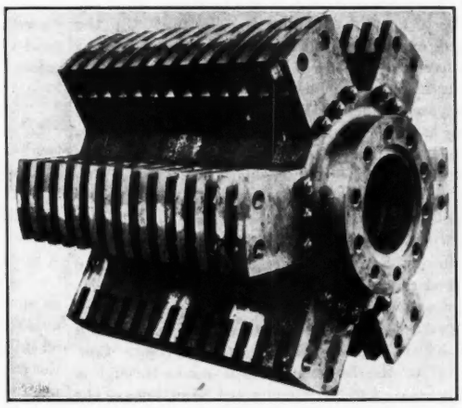


FIG. 17. ROTOR STAR-PLATE ASSEMBLY.

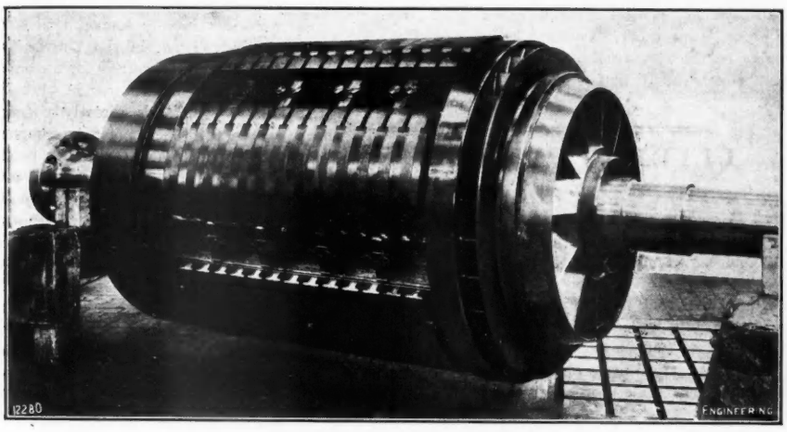


FIG. 18. COMPLETE ROTOR.

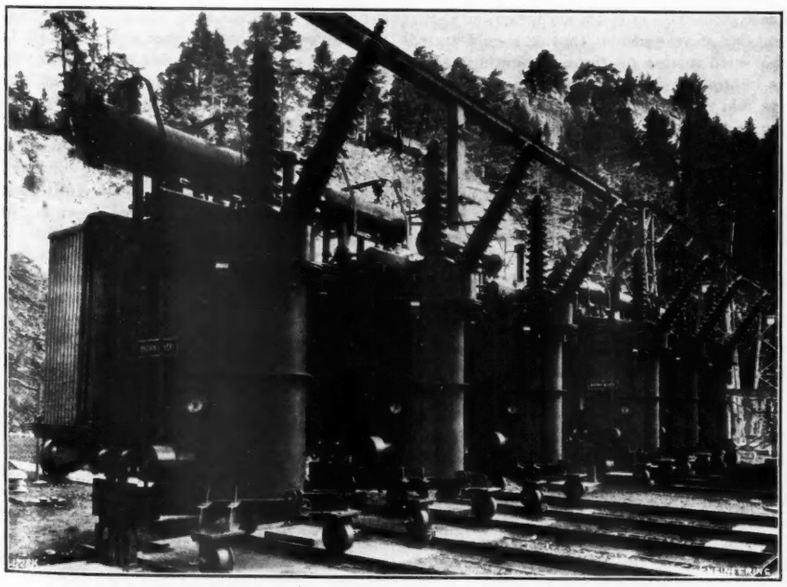


FIG. 19. TWO BANKS OF STEP-UP TRANSFORMERS.

samples were collected. These were examined at the Zürich Federal Institute of Technology for water content, compressibility, imperviousness, resistance to shear and other properties. Suitable material for all the zones was found within 1 km. of the site of the dam. Construction is now proceeding and it is expected that the dam will be completed in 1954. The work has involved the re-location of the road from Tiefencastel to Silvaplana, a mountaineering centre in the Upper Engadine. The construction of the new road involved the building of two reinforced-concrete bridges carried on stone piers. Preliminary work included the driving of a tunnel to divert the river from the site of the dam. All arrangements necessary before proceeding with the construction of the dam were completed in the autumn of 1950.

The height of the dam above the bed of the Julia River will be 70 m. and the length of the crown, 400 m. The total quantity of material required is estimated at 2·7 million cub. m., made up of 0·5 million cub. m. for the compacted central zone, 0·1 million cub. m. for the semi-impervious zone on each side of this, 1·8 million cub. m. of outside porous material consisting of washed and unwashed gravel and 0·3 million cub. m. of rock. The dam is expected to be completed in 1954. A curtain of grouting has been formed in continuation of the axis of the dam, in the west flank between elevations 1680 and 1638. The cut-off diaphragm wall, mentioned above, is of reinforced concrete 2 m. thick; it extends down to bedrock. It was constructed by sinking a series of rectangular vertical shafts, 3·1 m. by 2 m. They were formed in sections 1·3 m. deep, each section being lined with concrete 30 cm. thick, before the section below it was excavated. When the vertical shaft was completed it was filled with armoured concrete. The next vertical shaft, alongside, was then sunk until the whole diaphragm was built up. The concrete linings of the various shafts interlock, and extensive grouting was carried out sealing the diaphragm to the surrounding rock. A drainage tunnel has been driven below the diaphragm, any ground water collected being pumped into the river.

Observation shafts are being formed in the dam in order to detect any tendency to sliding or settlement of the material. Copper tubes connected to gauges are also being inserted to register the internal water pressure. The discharge from the reservoir formed by the dam will be through a circular tunnel, 3·5 m. in diameter, formed in the east flank of the dam; it will connect to an intake structure provided with a control gate. These arrangements will be installed shortly before the reservoir is filled. The tunnel in the east flank is being used to divert the river from the site of the dam during construction. High-level discharge will be over gate-controlled spillways situated on the east flank and entirely separated from the dam. They will connect to a vertical shaft, 4 m. in diameter, the lower end of which will connect to a horizontal tunnel leading to the bed of the Julia River.

The fall between high-water level in the reservoir and the tail race of the power station under construction at Tinzen is 483 m. The total length of

the feeder tunnel from the intake structure to the power station instrument house is 9,436 m. It follows the west flank of the mountain and is divided into three sections, the first extending from the intake to an adit at Faller is 2,400 m. long; the second extending from this point to an adit at Nascharegnas is 2,864 m. long; and the last section to the instrument house is 4,172 m. long. These places are villages in the Julian Pass. The adit at Faller has a length of 380 m. and that at Naschereg-nas one of 500 m. The adits are accessible by roads through the forest and by cableways. They will be kept open to permit inspection of the feeder tunnel and will be provided with steel gates.

It will be noted from Fig. 2, that the stream flowing down the Val da Faller has been connected to the feeder tunnel. The amount of water available is limited to 3 cub. m. per second. A weir has been built across the river bed; this is provided with a spillway and excess water passes to the river. Connection to the feeder tunnel is made through a vertical shaft 2 m. in diameter and 85 m. long. The water passes through a trash rack and de-silter before entering the shaft. Four other streams, flowing from the Alp Flix, are also diverted to serve the power scheme; they are indicated in Fig. 2. Each of the streams is provided with an intake comprising a weir and a de-silter. The water collected, which amounts to approximately 2 cub. m. per second, is led by a concrete conduit and an open flume directly to the Marmorera reservoir.

The feeder tunnel is circular in cross section with a flat bottom, about 1 m. wide. The internal diameter is 2·55 m. and the concrete lining 20 cm. to 30 cm. thick, the thickness depending on the nature of the rock formation through which the tunnel is driven. The section of the tunnel between the intake in the reservoir and gate house, which is situated on the bank, is 2·41 m. in diameter and is lined with granite. The average fall throughout is 3·7 per cent., but the fall varies slightly in different parts of the tunnel. There is a surge chamber at the north end of the tunnel at the point at which it connects to the penstock, and there is an instrument and valve house at this point. The length of the penstock from the valve house to the power station is 910 m. and the gradient is 87 per cent., approaching the vertical. The internal diameter gradually decreases from 1·80 m. at the top to 1·50 m. at the station. The upper part of the pipe is of steel, the wall thickness increasing progressively from 15 mm. to 29 mm. The lower part of the pipe, about 200 m. long, is made from chromium-copper alloy, the wall thickness increasing downwards from 19 mm. to 30 mm. The pipes were supplied in lengths varying from 8 to 10 m., and were welded when in position. The longitudinal seams were shop welded. The site welds were heat-treated with a gas flame to relieve any internal stresses and the pipes were then immediately embedded in concrete 25 cm. thick with a wire-mesh reinforcement. There are no expansion joints in the pipe, which is anchored in three concrete blocks, one at each end and the third in the centre. The total weight of the pipe, including the distributing branches in the power station, is 1,170 tons.

TINZEN POWER STATION.

The power station will contain two Escher Wyss 34,000-h.p. horizontal-axis Pelton-wheel sets running at 333⅓ r.p.m. The three-phase alternators, rated at 26,000 kVA, generate at 11,000 volts. Each set has two Pelton wheels overhung on each end of the main shaft carrying the generator. The flanges to which the Pelton wheels are bolted are forged integrally with the shaft. The hub diameter is 750 mm. The generators are of the totally-enclosed type with closed-circuit air circulation, the air passing over water-cooled coils. The stator body is built up of welded steel plates, the winding being of copper-grid construction with two conductors in each slot. The rotor body is made up of six discs attached to cast-iron centre pieces with spacers between the separate discs. The poles are attached by clamps in such a way that the pole pieces can be removed axially. The net available head varies between 387 and 448 m. and the water consumption between 4 and 3·15 cub. m. per second.

FUTURE DEVELOPMENTS.

In addition to the Marmorera development, two further schemes for the utilisation of the water of Oberhalbstein district are projected. They are both indicated in Fig. 2. The first envisages the utilisation of the stretch of the Julia River between Tinzen power station and the Burvagn reservoir. A power station would be built at Conters with a feeder tunnel approximately parallel to the river, as shown in Fig. 2. A head of 80 m. would be available, giving a yearly production of about 80 million kWh. The second scheme would utilise the waters of Lake Radons, which is situated to the west of Tinzen, and also those of the streams of the Val d'Err, providing some 136 million kWh per annum. The extra supplies would presumably be utilised by extending Tinzen power station. With the ultimate completion of these extra works, a total annual supply of 720 million kWh would be available to the city of Zürich from the Grisons area, of which nearly half would represent winter supply.

LITERATURE.

Aircraft Propulsion: Theory and Performance.

By A. W. MORLEY, M.Sc., Ph.D. Longmans, Green and Company, Limited, 6 and 7, Clifford Street, London, W.1. [Price 28s. net.]

THE title of this book has the virtue of brevity and suits its contents well enough, but, to the superficial glance, *Aircraft Propulsion* might suggest an emphasis on aerodynamic problems rather than on the means of generating propelling power. Actually, the book deals with the fundamental theory and the characteristics of aircraft propelling units in relation to the conditions in which they work, and is written for graduate rather than undergraduate students. It is not surprising, in view of present-day developments, that it should include only a small section on the reciprocating engine; it is a treatise chiefly on the gas turbine and the jet engine, and as such is highly commendable.

Appropriately, the first chapter is a statement of the nature of the drag of aircraft and an explanation of the factors that determine the required propelling thrust. The chapters which follow develop the basic thermodynamics and gas dynamics required for contemporary theories of the gas turbine and the jet engine. These chapters, in particular, are conceived presumably for the graduate student, for they are highly concentrated and explanatory matter is kept to a minimum. The chapter entitled "Introductory Gas Dynamics" runs to only 22 pages; it is an excellent resumé of the subject, but it is a pity that it does not develop a little more fully the relevance of this subject to aircraft propulsion and aircraft engines.

The system of symbols in use in thermodynamics and gas dynamics is already complex and it behoves writers to do nothing which might further complicate it. It is observed that, in one chapter of the book, the general symbol for a total head temperature is T_{tot}; but later, as the treatment develops, the symbol for a particular value becomes, say, T_{2t}. Why the numeral should come first in the subscript is difficult to see, though this form is also used by authors other than Dr. Morley. To distinguish one value of total head temperature from another, the use of T_{t1} and T_{t2} would be logical, for T_t is a suitable composite symbol for total head temperature in general.

The chapters on the turbo-jet engine, gas-turbine cycles and the propeller turbine and compound turbine are written with marked competence and are followed by a chapter on fairly conventional lines on axial-flow theory. Twenty-five pages are then devoted to an excellent chapter in which the performance of the reciprocating engine is analysed. The text is completed by two chapters contributed by Mr. A. P. B. Beeton on the ram jet and the rocket, which supplies in convenient form information which has not been made available hitherto in a text-book.

Public Health Engineering.

By PETER C. G. ISAAC, B.Sc.(Eng.), A.M.I.C.E., M.R.San.I. E. and F. N. Spon, Limited, 22, Henrietta-street, London, W.C.2. [Price 36s. net.]

PUBLIC-HEALTH engineering, as a subject for university courses, is a fairly recent innovation, and it was only in 1950 that the Institution of Civil Engineers decided to establish a Division within the Institution for its study and discussion. We have referred from time to time to the post-graduate courses on the subject instituted under Professor A. J. S. Pippard at the Imperial College of Science and Technology, but it may not be generally known that King's College, Newcastle-on-Tyne, in the University of Durham, has offered similar courses for a comparable period. Mr. Isaac, as lecturer in civil engineering at King's College, is directly concerned with them, and in this book presents compactly, and with a wealth of references for further reading, the civil-engineering side of the work of a public health engineer. The problems of water—potable or not, clean, or polluted with trade or other wastes—make up the greater part of the text, but sewerage, refuse disposal, district heating and atmospheric pollution are also discussed. This should be a useful book to engineers in search of general information on public health services, as well as for the students to whom it is primarily addressed.

The Design of Valves and Fittings.

By G. H. PEARSON, A.M.I.Mech.E., A.M.Inst.F. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 50s. net.]

WHILE we would not agree entirely with the author of this book, in these electronic days, that "Engineers will not require enlightenment as to what is meant by a valve," we do concur in his statement, with regard to valves and kindred fittings of the mechanical kind, that their detailed design "is a subject which does not appear to have engaged the attention of writers" to any great extent; for example, in the *Proceedings* of the Institution of Mechanical Engineers there has been no paper specifically devoted to safety valves since 1877, though there was an informal discussion on the high-lift type in 1939. It will be seen, therefore, that there is, *prima facie*, an opening for a text-book on the subject. Mr. Pearson is probably well aware that he has not covered the vast field with any approach to completeness, but this first edition may be welcomed as a good beginning, which, perhaps, subsequent editions may amplify.

After an introductory chapter and another on cocks, there are three on the design of screw-down valves, and one each on parallel slide valves, safety valves and relief valves, non-return valves, and reducing valves and surplus valves. The survey then switches to boiler water-level alarms, water gauges, pressure gauges, and other pressure-vessel mountings, after which the author turns to hydraulics and includes a chapter on hydraulic stop-valves and another on wedge-gate sluice valves. The last three chapters deal, respectively, with equilibrium float valves, valve chests, and gearing for manually-operated valves. Tables of British Standard pipe flanges for land use are given in an appendix, and steam tables in another. The line illustrations are

INVESTIGATION OF PRESSURE RISE IN PETROL ENGINES.

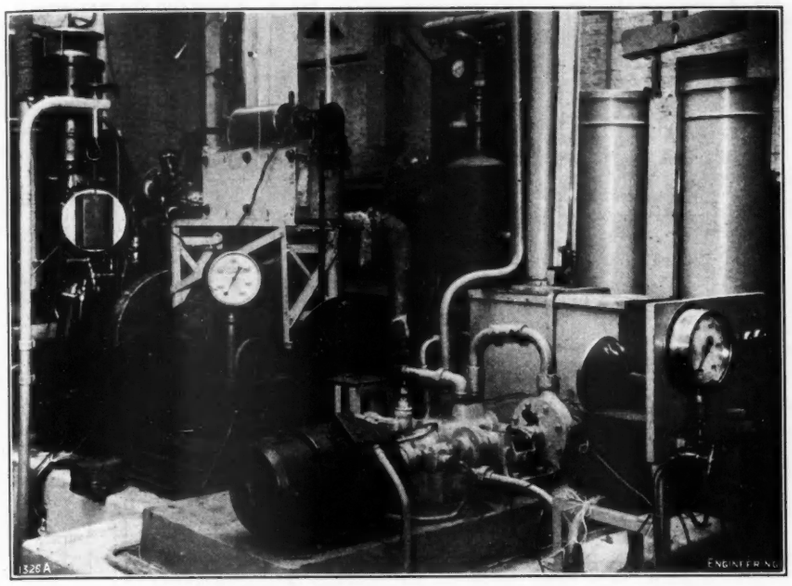
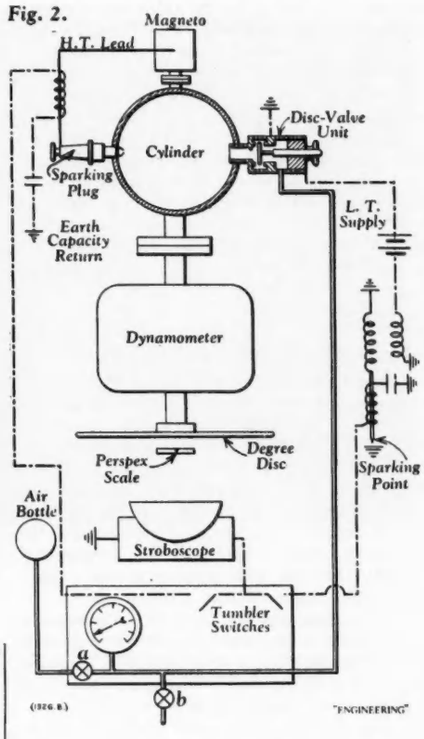


FIG. 1. ARRANGEMENT OF APPARATUS.



well chosen and commendably clear; though there seems no reason why the three designs which are reproduced as folding insets should not have been reduced to page size.

It will be seen from the summary of the contents, in the previous paragraph, that steam admission and exhaust valves are not discussed, which is understandable where the ordinary piston and slide types are concerned, since these are usually dealt with in books on steam and other reciprocating engines, of which there is no lack. It would have been an added attraction of the book, however, if some space had been devoted to steam-turbine control valves, which generically are within its scope; for instance, they form one of the most important applications of the double-beat principle, a type of valve that is dismissed rather briefly in a matter of three pages, and with no mention of the flexible-disc variety. In dealing with spring-loaded safety and relief valves, too, the author appears to have confined his attention to those of the familiar coil-spring type. This design has had a long life and, in general, has served its purpose well, but there are advantages in the use of the more recent torsion-bar type, especially for modern power-station boilers working at very high pressures, that would seem to deserve some mention.

THE LATE MR. WALTER YATES.—We regret to announce the death of Mr. Walter Yates, M.I.Mech.E., which occurred on July 11 at his home at Worsley, Lancashire. Mr. Yates, who was in his 89th year, was the chairman and governing director of Matthews and Yates, Ltd., heating and ventilating engineers, Swinton, Lancashire. He was educated first at St. Peter's School, and then at the Wesleyan School, at Swinton, from 1868 to 1880, and served his apprenticeship, from 1880 to 1885, in the works of William Tice at Ashton. During his apprenticeship, he attended a course of evening study at Manchester University. He joined the firm of Matthews and Yates as a draughtsman in 1885, being later promoted to the position of manager. He purchased the business of the Climax Air Propeller Co. in 1888, and became a partner in the firm of Matthews and Yates, on the amalgamation of the two concerns in 1890. On the registration of this firm as a limited company in the following year, Mr. Yates was appointed a managing director. He was elected a member of the Institution of Mechanical Engineers as long ago as 1899. He became a member of the Institution of Heating and Ventilating Engineers in 1900 and served as President for the 1909 session.

STROBOSCOPIC APPARATUS FOR INVESTIGATING PRESSURE RISE IN SPARK-IGNITION ENGINES.

By J. G. LAVENDER, Ph.D., B.Sc., A.M.I.Mech.E.

THE rate of pressure rise during the combustion process in a spark-ignition engine is largely responsible for determining the crank angle at which the maximum cylinder pressure occurs and this, in turn, affects the ultimate power output, the fuel economy and the knock-limited operation of the engine. Consequently, when testing such an engine under different operating conditions, it is extremely useful if the angle and magnitude of the peak cylinder pressure can be observed continually. The attainment of the peak pressure does not indicate the completion of the combustion process but denotes the point beyond which further pressure rise is prevented by the downward movement of the piston. As the spark normally occurs before the piston has completed the compression stroke, the final upward piston movement will assist the pressure rise during the initial stages of the combustion process while during the part of the combustion process after the top dead centre the volume of the combustion space will be increasing and the piston movement tends to cancel further pressure rise. Since, however, the pressure rise is normally limited to within about 15 deg. of crankshaft rotation on either side of the top dead centre, the piston movement and consequent change in combustion-space volume will be relatively small during this period.

Measurements of the rate of pressure rise are obtainable from the normal indicator diagram, but this method suffers from the disadvantage that for each reading taken a separate indicator diagram is required and as a result the variation in the rate of pressure rise cannot be continually observed during a change in operating conditions. An alternative method of measurement is offered by the use of a cathode-ray oscilloscope arranged to produce a continuous pressure-time recording, but in this case accurate calibration of the instrument becomes extremely difficult. The stroboscopic apparatus was designed to enable the ignition advance and the angle and magnitude of the peak pressure to be obtainable continually and accurately during a test, and so that the effect of alteration of any operating condition, such as mixture strength or ignition timing, could be seen immediately.

The apparatus, shown in Figs. 1 and 2, consists essentially of a stroboscopic lamp illuminating a large rotating disc attached to the dynamometer shaft; the lamp can be triggered by means of a small current applied to the contactor circuit. The disc, about 2 ft. in diameter, is accurately calibrated in degrees of crankshaft rotation, being carefully set on the shaft so that when the engine is in the top dead centre position the zero mark on the disc corresponds with a fixed vertical line scribed on a Perspex scale erected in front of the disc. Two triggering circuits are provided for the stroboscope, one circuit to measure the ignition timing and the other to indicate the angle of the peak cylinder pressure.

The circuit for the ignition timing is obtained by passing several turns of bell wire round the high-tension cable from the magneto (or distributor) to the sparking plug, and taking one end of this wire to the contactor circuit of the stroboscope, the other end forming an earth-capacity return to complete the circuit. The high-tension current, in passing to the sparking plug, causes a small induced current to be set up in the lead to the stroboscope, thereby triggering the lamp at the moment of the spark in the combustion chamber. The crank angle at which the spark occurs is then read directly from the rotating disc which appears stationary but displaced through the required angle.

The angle at which the peak cylinder pressure occurs is obtained from a circuit arranged in conjunction with a Farnborough disc-valve unit situated in an appropriate position in the cylinder head. The air pressure to the disc-valve unit, obtained from an air-bottle, is controlled by means of a throttling valve *a*, Fig. 2, and a fine bleed-air valve *b* situated on the control panel. A large scale pressure gauge records the air pressure applied to the disc-valve unit. A 2-volt low-tension current is supplied to the central electrode of the disc-valve

unit after passing through the low-tension windings of an induction coil. The body of the disc-valve unit and the negative terminal of the 2-volt cell are earthed so that as the disc valve moves between its two seats the low-tension circuit is broken, thus causing a high-tension current to be set up in the appropriate windings of the induction coil. The high-tension current is discharged to earth by means of a suitable sparking gap. A lead from the stroboscope contactor circuit is wound round the lead to the sparking gap so that as a spark passes across the gap an induced current is set up in the stroboscope lead causing the lamp to flash. A flash of the stroboscope lamp occurs every time the disc-valve moves from one seat to the other, or, in other words, every time the cylinder pressure is balanced by the air pressure. Thus, by regulating the air pressure applied to the disc-valve, the crank angles at which any cylinder pressure occurs can be read directly from the degree disc.

In order to measure the crank angle of the maximum cylinder pressure, the air pressure is increased until the disc-valve is held against its lower seat throughout the engine cycle and the stroboscope ceases to flash. Then, using the fine bleed-air valve, the pressure is gradually released until the disc-valve is just lifted from its lower seat by the maximum cylinder pressure and the stroboscope begins to flash. If the air pressure is reduced below the peak pressure the lamp gives two distinct flashes during a cycle, one as the pressure is rising and the other as the pressure is falling during the expansion stroke. It is possible therefore to determine, with reasonable accuracy, the setting of the bleed-air valve, so that the applied air pressure just balances the peak cylinder pressure. The peak pressure is then read from the pressure gauge and the crank angle is given by the apparent stationary position of the degree disc.

An average rate of pressure rise was calculated as the pressure rise from the instant of ignition to the maximum cylinder pressure divided by the angle of crankshaft rotation during this pressure rise. The cylinder pressure at the instant of the ignition is determined by setting the air pressure applied to the disc-valve to such a value that the stroboscope flashes at the same crank angle as that of the ignition advance, the required pressure being read directly from the pressure gauge. Calibration tests made with the stroboscope indicated that the ignition timing could be obtained to within $\pm \frac{1}{4}$ deg., and the peak pressure to within ± 5 lb. per square inch.

In Figs. 3, 4 and 5, results are plotted of a test using the stroboscope on a Ricardo E.6/R variable-compression engine to determine the settings of ignition advance and mixture strength to produce maximum power and maximum economy operation at a fixed speed and full throttle opening. The compression ratio was 5·0 and the speed 1,500 r.p.m. in each case. Fig. 3 indicates the variation in the angle of the peak pressure as the ignition was altered from fully advanced to fully retarded at different air-fuel ratios. Fig. 4 shows the variation in the rate of pressure rise against air-fuel ratio at different ignition settings and it is seen that for all angles of ignition advance the maximum rate of pressure rise occurred at an air-fuel ratio of about 12 : 1, i.e., about a 20 per cent. rich mixture. The peak values of B.M.E.P. given from Fig. 3 are replotted against mixture strength in Fig. 5, showing maximum power conditions at an air-fuel ratio of 12·1 and an ignition advance of 29 deg., such that the peak pressure occurred 12 deg. after top dead centre. These settings gave a rate of pressure rise of 10·2 lb. per square inch per degree. Maximum economy, or minimum specific consumption, was obtained with an air-fuel ratio of 16·6 and an ignition advance of 56 deg. producing the peak pressure 5 deg. after T.D.C., but giving a much lower rate of pressure rise.

PRESSURE RISE IN PETROL ENGINES.

Fig. 3. EFFECT OF IGNITION ADVANCE AND MIXTURE STRENGTH ON ANGLE OF PEAK PRESSURE.

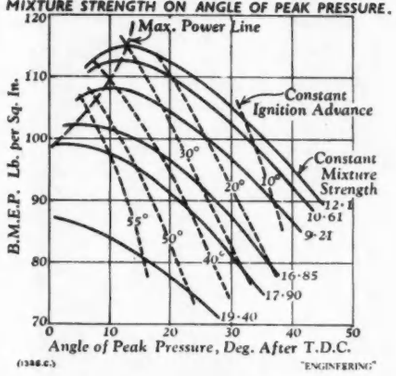


Fig. 4. EFFECT OF IGNITION ADVANCE AND MIXTURE STRENGTH ON RATE OF PRESSURE RISE.

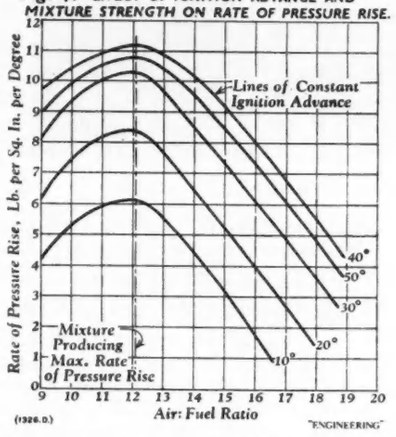
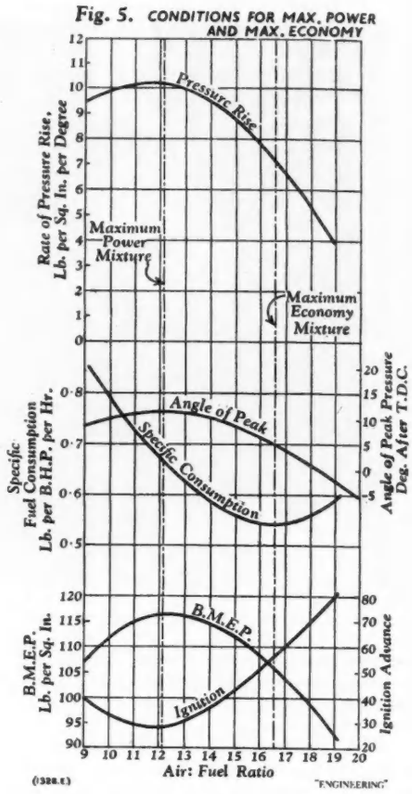

Lines of Constant Ignition Advance
Mixture Producing Max. Rate of Pressure Rise
Rate of Pressure Rise, Lb. per Sq. In. per Degree
Air: Fuel Ratio
"ENGINEERING"

Fig. 5. CONDITIONS FOR MAX. POWER AND MAX. ECONOMY



The ignition timing circuit of the stroboscope has been successfully used during tests on different engines for investigating the ignition advance characteristics given by centrifugal advance mechanisms and for detecting the difference in ignition timing between various cylinders of a multi-cylinder engine. This method has the great advantage that no direct drive has to be taken from the engine under test. The only necessary addition to the engine is a calibrated degree disc which, in most cases, is already provided by the engine flywheel. In such a case, a continuous record of the ignition timing may be obtained by passing a few turns of the stroboscope lead around the appropriate high-tension cable and directing the lamp on to the engine flywheel.

The work described above was carried out in the mechanical engineering laboratories of Queen Mary College (University of London), and the author wishes to express his thanks to Professor E. Giffen for his help and advice and to Mr. P. E. Hubble for assistance in conducting the tests.

"A SHORT PHILOSOPHY FOR JUNIOR MANAGEMENT."—A summary of those activities which come under the general heading of management, entitled *A Short Philosophy for Junior Management*, has been issued by the Triplex group of companies, which includes the Triplex Safety Glass Co., Ltd., Quickfit and Quartz, Ltd., Weldall and Assembly, Ltd., and Stern and Bell, Ltd. Although claiming to be no more than a brief outline of the subject, written primarily for the guidance of the supervisory staffs of the companies mentioned above, the booklet contains useful information of a kind likely to be helpful to foremen and junior managers over a much wider field. Under a series of some 30 headings, the booklet deals with such matters as research and development, the role of industry in the social pattern, wage structures, and the firm's profit-sharing fund. Copies may be obtained by approved applicants from the secretary, Triplex Safety Glass Co., Ltd., 1, Albemarle-street, London, W.1.

DUAL-FUEL ENGINES AT POINT OF AYR COLLIERY.

THE Point of Ayr colliery, which is situated on the Flintshire side of the estuary of the River Dee, is unusual in that a plentiful supply of rich methane gas is available from its virgin coal seams. This gas has been used for some time to generate steam, but to utilise it more efficiently five dual-fuel engines are to be installed. These engines, which are being constructed by the English Electric Company, Limited, Kingsway, London, W.C.2, will each have an output of 1,100 h.p. at a speed of 428 r.p.m. In basic design they will be of the firm's mechanical-injection Diesel type, but will be equipped with mixing apparatus for gas and air which will be connected to the air intake and linked with the governor. The normal fuel-injection equipment will be utilised to supply a pilot jet for igniting the methane. During operation, this will provide a proportion of the heat input, but the greater part will be obtained from the oil, the amount of which will be variable over a wide range. The gas will be drawn at a constant pressure from a Wiggins dry-seal type holder with a capacity of 250,000 cub. ft., but, should this supply fail, straight Diesel operation can be substituted without shutting the plant down. Waste-heat recovery boilers and heat exchangers are to be installed in the exhaust and cooling-water systems to increase the running efficiency of the plant as a whole.

The present average power requirements of the colliery can be met by three sets, which will normally operate in parallel, the fourth being brought in at times of peak load. The fifth will be available in emergency. The demand will be considerably increased when an electrically-driven winder has been installed in a new 350-ft. shaft and two existing steam-operated winders have been converted. All the ancillary plant, including three 5,000-cub. ft. capacity Belliss and Morcom compressors, will also be electrically driven. It is expected that, as a result of these changes, the operating costs of the colliery will be reduced appreciably.

RECEIVERS FOR BROADCAST MONITORING SERVICE.

FIG. 1. SUPERVISORY CONSOLE AT CAVERSHAM PARK.

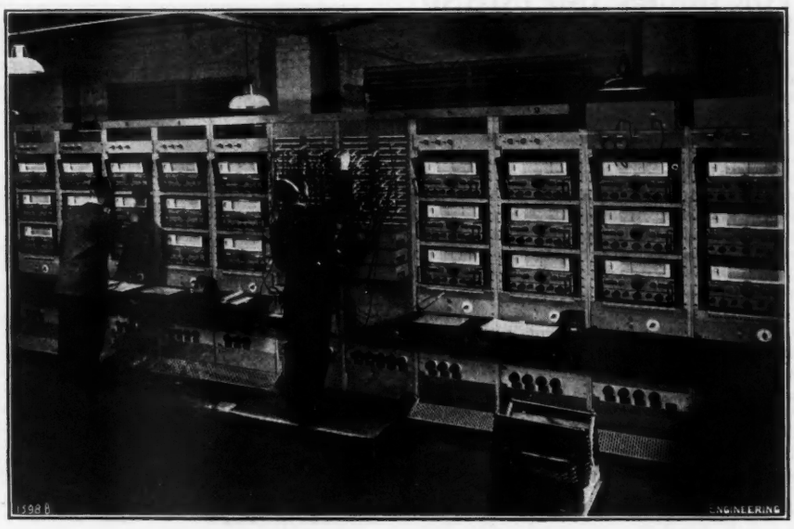


FIG. 2. MAIN RECEIVING BAYS.

RECEIVERS FOR BROADCAST MONITORING SERVICE.

As is probably common knowledge, the British Broadcasting Corporation instituted a monitoring service during the war for the purpose of listening to transmissions from foreign stations and thus assisting our military intelligence. The necessary equipment for this purpose, which was situated at Caversham Park, Reading, with a remote engineering interception station 3½ miles to the north at Crowsley Park, was retained after the conclusion of hostilities as a source of information for news bulletins. It has recently been extended and this extension, for which the General Electric Company, Limited, Kingsway, London, W.C.2, has supplied the necessary apparatus, consists of 30 receivers, 28 of which have been installed at Crowsley Park, which is an electrically quiet area where an extensive directional aerial system can be employed and two on a new supervisory console table in the main listening room at Caversham Park, a view of which is given in Fig. 1.

These receivers, which incorporate many circuit refinements and additional facilities, are of the 14-valve superheterodyne type with a frequency range from 150 kilocycles to 30 megacycles in six bands. The input impedance on all the bands is 75 ohms. There are six band widths for six decibel attenuation, three for 5·5, 9·0 and 13·0 kilocycles being for telephony, and three for 0·5, 1·0 and 2·0 kilocycles being for telegraphy. The last three have a crystal filter in the circuit between the mixer and the intermediate-frequency amplifier. By operating the filter phasing control an interfering signal only 1 kilocycle away from a wanted signal can be attenuated by at least 45 decibels. An outlet from the intermediate frequency amplifier at a suitable level and impedance (5 millivolts across 100 ohms) at a co-axial socket at the back of the receiver enables the equipment to be used for frequency shift keying. The tuning controls are fitted with locks to prevent any movement once adjustment has been made.

Compared with the earlier sets, the local oscillator frequency stability has been improved, as is shown by the fact that during extended drift tests results lower than the specified figures of 5 kilocycles at 29 megacycles, of 3 kilocycles at 19 megacycles and of 2 kilocycles at 8 and 3 megacycles were obtained. Actually, when the receivers reach a stable operating temperature still lower values than these are possible in practice. The local oscillator radiation has also been reduced to less than 250 microvolts. The receivers thus cater for the extremes of both high-quality telephony and long-distance telegraphy.

A general view of the main receiving bays at Crowsley Park is given in Fig. 2. Ten of the receivers at Crowsley have a built-in crystal calibrator which gives pips at 500 kilocycle intervals and is operated by a push-button on the front panel. All the receivers are fitted with chromium-plated "D" handles to facilitate removal from the racks for servicing.

LLOYD'S REGISTER SHIPBUILDING RETURNS.

THE shipbuilding returns compiled by Lloyd's Register of Shipping for the three months ended June 30, 1953, show that, at the end of June, 317 steamers and motorships, totalling 2,123,565 tons gross, were under construction in Great Britain and Northern Ireland, and 835 ships, of 3,913,867 tons gross, in the shipyards of other countries. As has been the case for a number of years, no figures are available for China, Poland or Russia. The total tonnage building in the United Kingdom is 9,338 tons less than in the previous quarter, and the tonnage in overseas yards is 42,013 tons more than at the end of March; such variations, of course, are to be expected between one quarter and another, and are not sufficient to be taken as indications of economic trends. It may be noted, however, that while, in the United Kingdom, work has been suspended during the quarter on only two vessels, totalling a mere 200 tons, the suspensions in overseas shipyards number 36, with a total tonnage of 60,847. On the other hand, for the third successive quarter there has been a reduction in the tonnage of orders outstanding in the shipyards of the British Isles, the decrease amounting to 63,613 tons. The proportion of oil tankers has fallen from 62·6 to 60·7 per cent.

Among the foreign shipbuilding countries, the United States has the largest tonnage under construction—658,086 tons, which is 71,575 tons more than in the previous quarter. Germany comes next with 545,329 tons, a decrease of 14,233 tons. No other country has more than half a million tons in hand, the respective totals, with increases and decreases shown in brackets, being as follows: the Netherlands, 450,683 tons (— 2,300 tons); Italy, 384,958 tons (+ 29,978 tons); Sweden, 374,832 tons (+ 27,977 tons); France, 369,123 tons (+ 22,644 tons); Japan, 335,487 tons (— 115,075 tons); Norway, 173,401 tons (+ 15,797 tons); Spain, 144,112 tons (+ 23,045 tons); Belgium, 143,263 tons (+ 3,155 tons); Denmark, 115,845 tons (— 17,192 tons); and Canada, 107,210 tons (+ 2,190 tons). A feature of some interest to economists is the amount of tonnage that is being built for delivery to countries other than those of the builders. Of the world total of 1,152 vessels, of 6,037,432 tons gross, 1,957,881 tons is to the order of other countries; and of that exported tonnage, 32·5 per cent. is being built in the United Kingdom.

Oil tankers under construction in the United Kingdom numbered 110, of 1,212,052 tons; this represents 57·1 per cent. of the total tonnage in hand, but is 13,725 tons less than in the previous quarter. Overseas countries are building 196 tankers, totalling 2,208,180 tons, which is 166,698 tons more than at the end of March and 56·4 per cent. of the total tonnage being built abroad. This total includes 27 tankers, of 396,021 tons, in hand in the United States of America; 26, of 335,252 tons, in Italy; 25, of 282,950 tons, in Sweden; 25, of 227,969 tons, in Germany; 16, of 216,178 tons, in France; 14, of 211,740 tons, in Japan; and 22, of 210,161 tons, in the Netherlands. The total number of tankers under construction in the world—306, of 3,420,232 tons, which is 152,973 tons more than at the end of March—comprises 127 steamships, of 1,764,241 tons, and 179 motorships, of 1,655,991 tons; and represents an increase from 54·4 to 56·7 per cent. of the world tonnage under construction. Eighty-three of the tankers, of 909,856 tons, are for registration in the United Kingdom; 49, of 462,543 tons, for Norway; 29, of 362,351 tons, for the United States of America; 23, of 328,952 tons, for Italy; 19, of 313,920 tons, for Panama; and 13, of 211,508 tons, for Liberia.

The analysis of types of propelling machinery shows that there are under construction in the world 25 steamers and 60 motorships of between 6,000 and 8,000 tons gross each; 42 steamers and 33 motorships of 8,000 to 10,000 tons; 64 steamers and 109 motorships between 10,000 and 15,000 tons; 36 steamers and 13 motorships between 15,000 and 20,000 tons; and 27 steamers and three motorships between 20,000 and 30,000 tons. Of the total under construction in the United Kingdom, 1,056,423 tons gross consisted of steamships and 1,067,142 tons of motorships. The corresponding figures for overseas yards were 1,860,117 tons of steamships and 2,053,750 tons of motorships. Of the total world construction, 3,815,961 tons, or 63·2 per cent., were building under the survey of Lloyd's Register (including ships to British Corporation class). The amount of United Kingdom new construction that is intended for classification with the Society is 1,994,663 tons (93·9 per cent. of the tonnage being built there) and, of the ships building abroad, 1,821,298 tons, or 46·5 per cent.

RESEARCH LABORATORY FOR DOCKS AND INLAND WATERWAYS EXECUTIVE.

As reported on page 120, of our last week's issue, a new hydraulic research laboratory was opened by the Rt. Hon. Lord Hurcomb, G.C.B., K.B.E., chairman of the British Transport Commission, on July 17. The immediate problems to be dealt with are concerned with improving the design of lock gates, sluices, water embankments and waterways craft. Working in conjunction with other research departments belonging to the Commission, the laboratory will also examine methods of arresting corrosion due to the action of sea water and will study new methods of protecting timber structures from damage caused by marine borers.

The new laboratory has been built in the grounds of the Bull's Bridge depot, Hayes, belonging to the south-eastern division of the Executive; the brick building is 126 ft. long and 45 ft. wide and has a lightweight roof of corrugaged asbestos sheet, with north lights carried on a system of saw-tooth trusses. All the glazing is of frosted glass and strip lighting has been used throughout. The principal equipment so far installed in the laboratory includes a wave tank with a pneumatic breakwater, a model of a stretch of the River Severn just above Bevere Lock, a model waterway to investigate the effects of power-station operation on the temperature of the water, and a barge-testing tank. The river model forms the centre foreground in Fig. 1, with the wave tank behind it; the barge-tank is on the right and the model waterway on the left of the same illustration. The barge tank extends for nearly the whole length along one side of the laboratory; is fairly standard in type and will be used to experiment with new hull forms, in particular regarding their backwash, which is important for barges continually used on narrow waterways where scouring of the banks is serious.

At Bevere Lock, on the River Severn, the amount of material to be dredged each year from the upstream approach to the lock is as much as that dredged from the approaches to the other four river locks put together. The model represents about a one-mile stretch of the river; the longitudinal scale adopted is 1 in 120, or 44 ft. to the mile, and the vertical scale, 1 in 40. The water levels in different parts of the model and water depth over the weir, and various discharges, accurately represent those observed and preliminary experiments are now proceeding to ensure that the rates of silt deposit in the different sections of the model correspond to those in the river. Calibration of the velocity-measuring instruments is also in hand. It is hoped that the model will throw light on river silting generally and, in particular, enable successful methods to be devised to avoid that at Bevere Lock without doing harm elsewhere.

The possibility of calming sea waves by many small air bubbles rising through the water has long been known to civil engineers, but the method has seldom been adopted in practice because, where it has been used, the results have been erratic. Small areas of relatively calm water in otherwise rough seas may be provided in many ways, but all except two of these require some form of fixed or floating breakwater and are therefore to some extent obstructions to the free movement of shipping. Where the navigation channel is too narrow to permit any obstruction—for example, in the immediate approaches to dock and harbour entrances—the waves may be calmed by spreading oil on the surface of the water or by the alternative of a pneumatic breakwater such as that now to be investigated in the wave tank at the new laboratory. Oil on the surface retards the breaking of the waves lashed by a strong wind, but has little effect in lowering their height. The pneumatic breakwater, when successful, actually lowers the height of the waves as can be seen from Fig. 2.

During the repair work to one of the gates of the train-ferry dock, Dover, at the end of 1952, a full-scale experimental pneumatic breakwater showed signs of successful operation. The conditions existing at that particular site, however, are not typical, and the same success elsewhere could not be predicted with confidence as insufficient is known about the action of this type of breakwater.

The fourth major piece of equipment already installed in the laboratory is a thermo-hydraulic model of a section of the River Calder and of the Aire and Calder Canal. In 1952, a proposal was put forward to erect a new power station close to the river and to draw on the stream for cooling water. It was feared, however, that the rejected water might then be too warm for use as cooling water at power stations already existing downstream, from whom dues were already received by the Executive. It was also thought likely that the warmed water might give rise to fog over the waterway in cold weather. The model represents about a mile of the relevant section of the river and canal to a scale of 1 in 146 (nearly 36 in. to a mile) longitudinally, 1 in 118 (just over 1 in. to 10 ft.) laterally and 1 in 24 vertically. The model has been so adjusted that, other conditions being equal, the fall in temperature along corresponding sections of the waterway and model are the same. It was found that the results obtained on the model agreed sufficiently closely with variations observed on the water and it has been possible to construct a graph relating the difference in temperature between the water and the surrounding air, at any point along the canal, with the period of flow. Thus, knowing the excess temperature of the water at the locality of the proposed new power station and the rate of flow of the river it is possible to deduce the likely temperature of the water in the vicinity of the existing stations. Close agreement was obtained between these experiments and some theoretical work by Galavics and Fejér.*

Although the laboratory has only just been put into commission, the research department of the Executive has been active since 1950. Assistance has been given to the local officers of the Executive on many problems, and a quarterly bulletin has been issued containing notes on relevant technical developments. The part that the department can play in bringing about the re-development of the canals of the United Kingdom is almost unlimited and it is this aspect of their work that could be made to pay the greatest dividends.

* "Der Temperaturausgleich im Flüssen im Zusammenhang mit Warmepumpen," by Von F. Galavics und G. Fejér, *Schweitze Archiv für Angewandte, Wissenschaft und Technic*, September 1945, page 269, and October 1945, page 302.

HYDRAULIC RESEARCH LABORATORY.

FIG. 1. GENERAL VIEW OF LABORATORY.

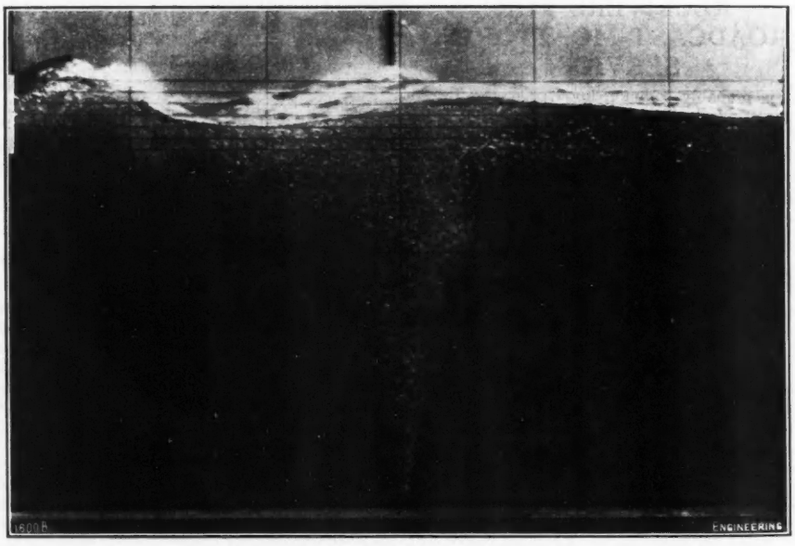


FIG. 2. PNEUMATIC BREAKWATER IN WAVE TANK.

LONDON'S AIRPORTS.

ON July 22, in a statement to the House of Commons, the Rt. Hon. A. T. Lennox-Boyd, Minister of Transport and Civil Aviation, re-affirmed the Government's intention to develop Gatwick Airport as the southern alternative to London Airport, but, as a result of discussions with various local authorities, the Crawley Development Corporation, and the Railway Executive, the present plans have been modified from the scheme originally proposed in a memorandum published by the Ministry of Civil Aviation in October, 1952. The capital cost of developing Gatwick Airport is estimated at about 6*l.* million, to be spread over the next seven years.

The reasons for the Government's decision to proceed with the development of Gatwick Airport are given in Cmd. 8902, *London's Airports*, published by H.M.S.O., price 6*d.* net. At present, there are seven airports in the London area controlled by the Ministry of Civil Aviation—London Airport, Northolt, Blackbushe, Bovingdon, Croydon, Gatwick and Stansted. The rapid growth of air traffic centred on London—which has grown from 109,000 movements in 1947 to nearly 161,000 in 1952, and may well be doubled within the next ten years—has resulted in a heavy load on the air-traffic control organisation. In a few years' time, unless radical changes are made, the organisation will not be able to provide a safe and efficient service. To simplify the air traffic pattern, therefore, the Government propose to reduce the number of London's civil airports to three—London Airport, Gatwick, and Blackbushe; Stansted airport will be held in reserve. Northolt Airport, separated by only five miles from London Airport, will be returned to the Royal Air Force, and only a limited amount of flying will take place there. Civil flying will also stop at Bovingdon and Stansted, and Croydon will be abandoned and sold for other purposes.

The main considerations governing the selection of an alternative airport, which will be used mainly for taking some of the summer seasonal traffic from London Airport, and for receiving aircraft diverted from London Airport during periods of bad visibility there, are as follow: the alternative airport should have good visibility when that at the main airport is bad, it should have convenient and rapid access to London, it should lie on the main air routes serving London, should offer no intractable traffic problems, and should create as little disturbance as possible to the amenities of the surrounding district. Of all the possible airports considered within a radius of about 50 miles from central London, Gatwick most nearly fulfils all these requirements.

One of the principal objections raised against the original scheme to develop Gatwick concerned the proposal for a costly diversion to the west of the Brighton road. In the modified plan, the main east-west runways are swung through 5 deg. counter-clockwise as compared with the original plan, and the eastern end of the northern runway would be 2,900 ft., and that of the southern runway 2,200 ft., farther to the west. By this means, a westerly diversion of the Brighton road would no longer be required; it is proposed to carry out instead an easterly diversion so that the road will run between the railway and the eastern end of the two main runways. The construction of such a road will be necessary in any case, to provide access to the airport and railway station.

The proposed layout, then, is two main runways in a direction slightly south of the east-to-west line, the main southern runway to be 7,000 ft. long and the northern runway (which will only be constructed if traffic warrants it) to be 6,000 ft. long, the two runways being separated by 3,000 ft. A third subsidiary 4,000-ft. runway, running north east to south west, may be constructed if it is found to be desirable, and this runway would be 2,900 ft. farther west than in the original scheme. The terminal building and aircraft-parking aprons would be sited close to Gatwick Racecourse station, as in the original scheme. The new hangar and workshops will be about a quarter mile farther north than in the original scheme. A new maintenance area in the south-east corner of the airport, north of the existing maintenance area, is envisaged, but the existing hangars will have to remain in use for some years.

Gatwick is to be developed in two stages: in the first, the main southern east-west runway and associated taxiways will be constructed, with the aircraft-parking space, the main terminal building, and sufficient hangar space to enable Croydon Airport to be released for sale. The maintenance area will then be developed and, if it is needed, the north-east south-west runway will be constructed. It is expected that this will follow closely on the completion of the first phase of stage 1. Except for the hangars, this phase should be complete by 1958, by which time the Brighton-road diversion would have been provided. In the second stage, the northern runway and additional taxiways and parking space would be constructed, if traffic demands it. It is considered unlikely that the second stage of development, if it ever becomes necessary, would be completed before 1965.

In addition to the diversion of the London-Brighton road, two other road diversions will be required during stage 1—the Lowfield Heath–Tinsley Green road and the Charlwood–Lowfield Heath road. (This latter diversion was not called for in the original plan.) If the second stage of construction is undertaken, it will also be necessary to divert the Povey Cross–Charlwood road. The new layout requires rather more land than did the original scheme—about 645 acres, compared with 540 acres, for the first stage of development, and about 1,050 acres, compared with 870 acres, for the full development of the airport. (These figures include the area of the existing aerodrome, 400 acres.) Rather more than half the land will still be available for grass drying and other agricultural purposes. The re-orientation of the southern runway will, unfortunately, make it necessary to demolish a number of houses.

Aircraft using the southern runway will not fly over any built-up areas. If the northern runway is required, aircraft will fly close to Charlwood, but not so close as in the original plan. The new subsidiary runway will take aircraft away from the direct line over Horley and Crawley, and the new maintenance area will reduce the possibility of noise nuisance affecting Crawley. Since Gatwick is to be mainly a diversionary airport, and for short-distance services which will operate only in the summer months and during daylight, it is considered that the disturbance arising from low-flying aircraft will not be excessive. Nevertheless, the Government intend to arrange for a public local inquiry to be held for the purpose of hearing local objections to details of the scheme.

OVERHAUL LIFE OF "GHOST" JET ENGINES.—As a result of experience acquired during the first 13 months of commercial operation of Comet air liners by the British Overseas Airways Corporation, the de Havilland Ghost jet engines installed in Comet aircraft in service with both B.O.A.C. and Union Aéromaritime de Transport (France) have now been officially approved for a life between overhauls of 600 hours. B.O.A.C. are now running trials on a batch of engines to extend the life to 750 hours.

ROYAL SOCIETY RESEARCH APPOINTMENTS.—Among a number of research appointments made recently by the Council of the Royal Society, we note that Mr. P. J. Black, B.Sc., of the University of Cambridge, has been appointed to a Mr. and Mrs. John Jaffe Donation Studentship, to carry out research on the structural studies of intermetallic compounds at the Crystallographic Laboratory, Cavendish Laboratory, Cambridge; Mr. J. R. Cross, of University College, Swansea, has been appointed to a similar Studentship to carry out research on the physical chemistry of cell processes at the Physical Chemistry Laboratory, University of Oxford; Mr. A. E. Litherland, B.Sc., of Liverpool University, has been appointed a Rutherford Memorial Scholar to carry out research on fast neutron spectroscopy with Atomic Energy of Canada, Ltd., Chalk River, Canada; and Mr. B. J. Robinson, B.Sc., of Sydney University, also has been appointed a Rutherford Memorial Scholar, to carry out ionospheric research at the Cavendish Laboratory, Cambridge. The financial provision for Mr. Litherland's scholarship is being made by Atomic Energy of Canada, Ltd., with whose agreement the Council of the Royal Society have conferred on Mr. Litherland the title of Rutherford Memorial Scholar.

DIESEL-ELECTRIC LOCOMOTIVES FOR NEW SOUTH WALES.

TEN 1,000-h.p. Diesel-electric locomotives which are now being built in this country for the New South Wales Government Railways, have been designed for shunting duties as well as for hauling very heavy freight trains. As the former duty necessitates absence from the shed for long periods, the equipment is simple and robust, while the provision of a double power unit enables one set to be shut down during periods of light duty, thus making for economy in operation. A further advantage of this arrangement is that small multi-cylinder engines can be used, thus reducing the weight and bulk of the components and facilitating overhaul.

A general view of one of these locomotives, the mechanical parts of which were constructed at the works of the Metropolitan-Cammell Carriage and Wagon Company, Limited, Birmingham, is given in Fig. 1, on page 140. As will be seen, they are of the Bo-Bo type. They are 47 ft. 2¾ in. long over the coupler faces and 25 ft. long between the bogie centres. The bogie wheelbase is 8 ft. 9 in. and the diameter of the wheels 3 ft. 6 in. The overall width is 9 ft. 6 in. and the overall height 13 ft. 11⅛ in. The approximate weight in running order is 80 tons.

The main frame is an all-welded structure of rolled-steel sections, plates and fabricated units, and is designed to accommodate the New South Wales Railways' centre couplings. Side buffers are also fitted. The four-wheeled bogies, which are illustrated in Fig. 2, are also of fabricated all-welded construction and carry swing bolsters fitted with triple coil springs. The side suspension is through beams which are mounted above the axleboxes and are connected to auxiliary coil springs at the outer ends. The inner ends of both beams on each side are coupled through links to a long laminated spring, which is secured centrally below the side frame. A motor, which drives the wheels through gearing, is mounted on each axle and is nose-suspended through links and Silentbloc bushes from cross-bars. The gearing is designed to allow some torsional resilience between the wheel centres and the tooth rim. The wheels themselves have solid centres with separate tyres and the axles are arranged to run in Skefko self-aligning roller-bearing boxes. The cast-steel centre pivots, side bearers and bolster-suspension pins are lubricated through grease nipples on each side of the bogie and underframe.

As will be seen from Fig. 1, there is one driver's cab in the centre of the locomotive, the floor of the cab being raised above the normal level of the frame. Visibility is thus improved and accommodation is provided below for the brake gear and other equipment, access to which is obtainable through trap doors. The power unit is housed under a bonnet, the hinged doors of which can be removed when required to facilitate maintenance. A large section of the roof is also removable, so that a complete engine-generator set can be lifted out. Smaller sections can also be removed to enable the engine to be overhauled *in situ*, the compressor to be changed, or the control frame examined. Two electrically-driven blowers are also housed under each bonnet for the forced ventilation of the traction motors.

One engine-generator with its radiator is fitted at each end of the locomotive. The layout is therefore symmetrical, except that at one end the control frame is next to the cab and at the other the electrically-driven compressor. The engine-generator sets, one of which is illustrated in Fig. 3, on page 140, comprise a Diesel engine constructed by Davey, Paxman and Company, Limited, Colchester, and developing an output of 500 h.p. when running at 1,250 r.p.m. The twelve cylinders, which have a 7-in. bore and 7½-in. stroke, giving a maximum piston speed of 1,615 ft. per minute, are arranged in V-form and are normally aspirated. The crankcase is a single casting, which carries an underslung crankshaft the bearings being protected against side thrust by deep fitting faces. In addition to the usual retaining studs, the main-gearing housings are secured by transverse tie rods which pass

1,000-H.P. DIESEL-ELECTRIC LOCOMOTIVE FOR NEW SOUTH WALES.

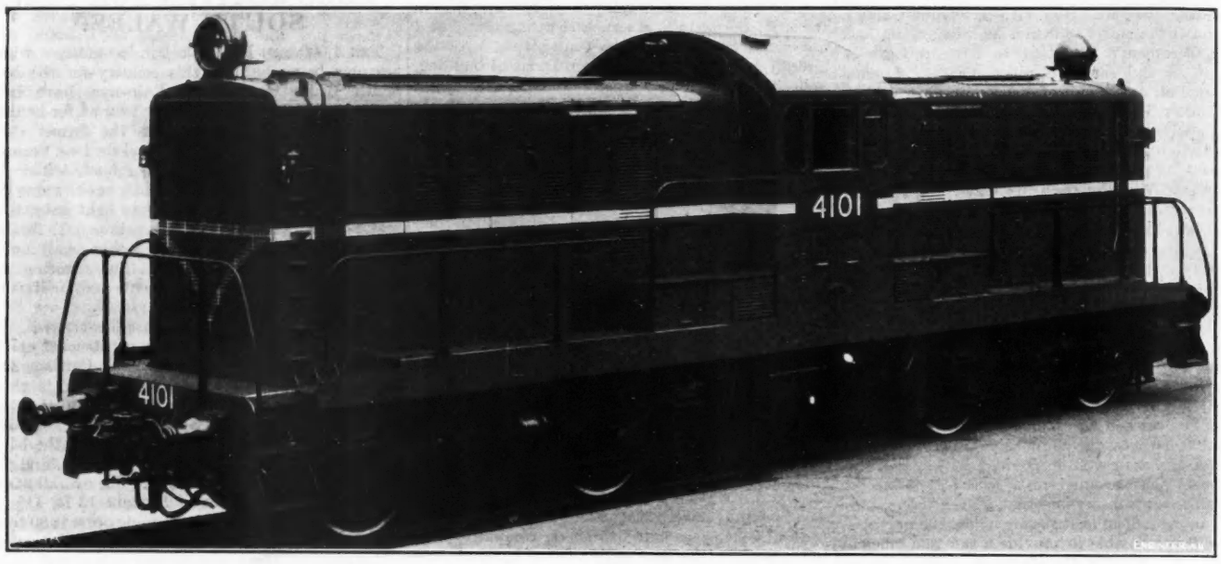


FIG. 1. GENERAL VIEW OF LOCOMOTIVE.

horizontally through them to the outside of the crankcase. The cylinder blocks, which are of cast iron, each include three bores fitted with dry-type liners. The single unit heads, which are of the same material, support the inlet and exhaust valves and incorporate the Ricardo Comet Mark 3 combustion system. The fuel pumps are of the C.A.V. Monobloc type, each containing six elements and are gear-driven from the cam shaft, which is operated by a chain from the crankshaft. A fuel tank of 500 gallons capacity is suspended from the frame immediately below the cab and oil is pumped from it by two electrically-driven Varley pumps to a pressure vessel with a return valve set to 10 lb. per square inch. A hand-priming pump is also fitted. Each engine is further provided with a gear-type boost pump to ensure a supply of fuel under positive pressure to the injection pump galleries. Forced lubrication is supplied from two engine-driven pumps, which are located in the sump and transmit oil at a pressure of either 80 lb. or 50 lb. per square inch. These pumps also supply oil to a centrifugal hydraulic servo governor, which is designed so that, if the pressure fails, the engine will be automatically shut down. Cooling is effected by Serck radiators, which are mounted at the outer ends of the locomotives, the fans being belt driven from the engine crankshaft. The cooling water is circulated by a centrifugal pump which is gear driven from the engine; thermostatically-controlled valves are embodied in the system and by-pass the radiator when the circulating water temperature falls below about 140 deg. F. The engine intakes draw air in through the roof and withdrawable filters. Special silencers are mounted under the centre portion of the roof.

The main generators, which were constructed by the British Thomson-Houston Company, Limited, Rugby, have been specially designed for the severe duties associated with Diesel-electric traction. They have a self-aligning roller bearing at the commutator end of the shaft, the other end being solidly coupled to the engine crankshaft. The magnet frame is of the fabricated type and carries supports for the auxiliary generator and overhung speed-sensitive exciter, both of which are belt driven from the main-generator shaft. A differential series winding, a self-exciting winding and a field winding, which is supplied from the exciter are provided. With this arrangement a very small drop in the engine speed is sufficient to reduce the load to a point where the engine power and generator output are balanced. Insulation is Class "B" throughout, and consists entirely of mica, glass and asbestos treated with varnish. Cooling air is drawn in

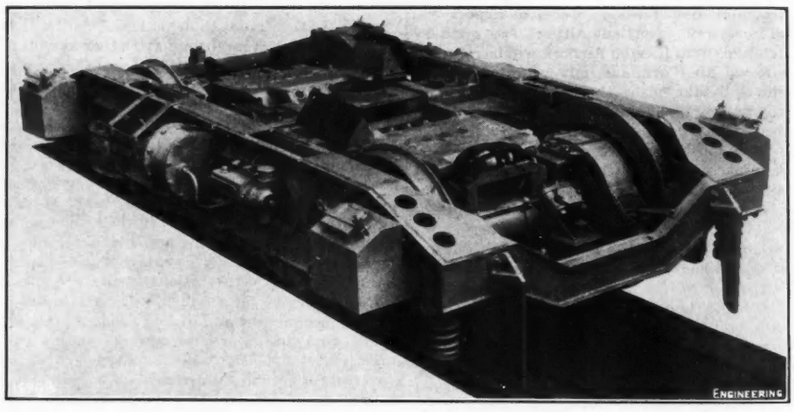


FIG. 2. FOUR-WHEELED BOGIE.

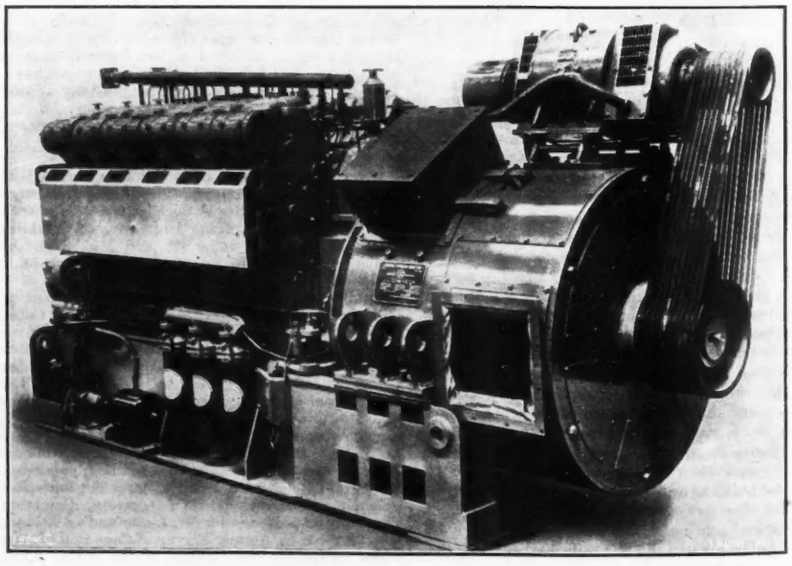


FIG. 3. ENGINE AND GENERATOR.

1,000-H.P. DIESEL-ELECTRIC LOCOMOTIVE FOR NEW SOUTH WALES.

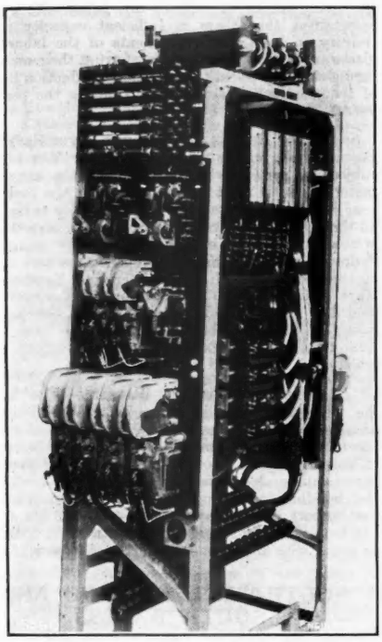


FIG. 4. CONTROL FRAME.

FIG. 5. INTERIOR OF DRIVER'S CAB.

through filters and after passing through the generator is discharged into the main compartment. Each engine-generator set is mounted on a common bed, which is supported on the main locomotive frame through Neo-K-Tex pads and resilient mountings. End stops are welded to the floor plate at each corner of the bedplate to prevent displacement. The traction motors, which are of conventional box-frame construction, are series wound and are forced-ventilated by electrically-driven centrifugal blowers. Class "B" insulation is used throughout.

Control is effected from a single cab which, as will be seen from Fig. 1, is in the centre of the locomotive, thus giving good visibility in both directions of running. This cab, a view of which is given in Fig. 5, is panelled throughout and insulation is provided between its inner and outer walls. Access doors to it are at the opposite corners, immediately behind the driving positions, the latter being in duplicate to enable operation to be effected from either side. Access to the cab and the engine housings is also obtainable by chequered walkways and there is a shunter's platform at each end. There are fixed driving windows at both ends with two fixed windows and one full-drop window at the sides to provide maximum look-out for the crews. Heating is by two radiators, which are supplied with engine cooling water. The equipment at each of the two driving positions consists of a power controller, key-operated reverse drum and instrument panel. There are also air-operated sanding and whistle valves. The reverse key is removable in the "off" position only and can only be moved when the power handle is also in the "off" position. In addition to "forward" "reverse" and "off" positions, it has an "engine only" position, which enables the engine to be run up and the controls tested without applying power to the motors. The power handle can only be operated when the reverser key is in either the "forward" or "reverse" position.

The starting switches, meters and gauges associated with the two engines are mounted on a panel in the cab, and warning lamps are fitted to show if a motor blower stops, if the engine oil pressure is too low or if the cooling-water temperature is excessive. Starting is effected by motoring a main generator from an Exide lead battery, interlocks being provided to ensure that only one engine is started at a time to prevent overloading. The duplicate control equipment is mounted on a framework under one bonnet. It comprises the electro-magnetic contactors, the air-operated reversing switch, the field diverter resistors and various relays, a view of which is given in Fig. 4. Couplers are fitted so that two locomotives can be controlled by one driver as soon as the engines have been started. No "dead man's handle" is provided as it is intended always to have a second man in the cab.

The braking equipment, which is of the Australian Westinghouse type, is arranged for multiple working. There are therefore two brake valves at the driver's position, one automatic for multiple operation and to apply the train brakes; and the other for the independent operation of the locomotive brakes during shunting. Air is supplied from an electrically-driven Hamworthy two-stage two-crank compressor to four 12 in. by 8 in. brake cylinders and thence to clasp brakes on each wheel. There is also a hand brake.

COOPERS HILL WAR MEMORIAL PRIZE AND MEDAL.—The Council of the Institution of Electrical Engineers have awarded the Coopers Hill War Memorial prize and medal for 1953 to Mr. G. Lyon, M.Sc. (Eng.), A.M.I.E.E., for his paper on "Some Experience with a British A.-C. Network Analyser." These prizes were founded by members of the Royal Indian Engineering College, Coopers Hill, in commemoration of members who were killed in the first world war. They are awarded annually by the Institution of Civil Engineers, and triennially, in turn, by the Institution of Electrical Engineers, the School of Military Engineering, Chatham, and the School of Forestry, Oxford.

DIRECT-ON-LINE CONTACTOR STARTER.—A direct-on-line contactor starter for use with single-phase or polyphase non-reversing squirrel-cage motors with outputs up to 5 h.p. at 200/550 volts and 25/60 cycles has recently been marketed by the British Thomson-Houston Co., Ltd., Rugby. It is suitable for applications where the starting current does not exceed eight times the full load value and permits a sustained overload of 25 per cent. to be carried. Control is effected by push-buttons which actuate a triple-pole contactor with an auxiliary retaining switch. Silver-faced double-break contacts are used. Under-voltage and overload protection is provided and the unit is enclosed in a cast-aluminium box which can be arranged for either wall or flange mounting.

ELECTRIC DEVELOPMENT ON INTER-NATIONAL RIVERS.

THE United Nations Economic Commission for Europe have reported that the representatives of 16 countries who attended a recent meeting of the Commission's Electric Power Committee adopted unanimously a recommendation designed to overcome difficulties that might arise from the development and utilisation of rivers that are of concern to more than one country. According to a communication that we have received from the London office of the United Nations, at Russell Square House, Russell-square, London, W.C.1, the recommendation was that "a State proposing to embark within its own territory on projects likely to have serious repercussions on the territory of other States, whether upstream or downstream, should first communicate to the States concerned such information as would enlighten them as to the nature of these repercussions"; which seems such obvious common-sense, apart from any question of international courtesy, that a formal resolution hardly appears to be necessary. The adoption of the recommendation is hailed, however, as "an important step towards the establishment of rules of international public law" and one "calculated in particular to permit the opening of negotiations between the parties in the interests of the harmonious hydro-electric development of 'successive' rivers in Europe."

At the same meeting, the secretariat was requested to continue its studies of the harnessing of rivers which form a common boundary between two or more countries, and to prepare an analysis of the most recent agreements in that field. A case in point was among the agenda, in the form of a report on the outcome of negotiations between Austria and Yugoslavia concerning the hydro-electric development of the river Drave, which flows between them. It was noted that progress had been made in reaching agreement on rules for exploiting hydro-electric installations on the river and that efforts were being made to overcome a grievance arising from a previous exploitation of the river.

BRITISH PURCHASES OF COAL FROM ABROAD.—The National Coal Board announced on July 23 that they had bought 200,000 tons of good quality coal, suitable for domestic use, from Belgium. This is in addition to the 300,000 tons recently ordered from France.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

SCOTTISH TRADE WITH CANADA.—Sir Alexander M'Coll, of the London committee of the Scottish Council (Development and Industry), will lead a Scottish industrial mission which is to spend September in Canada, investigating the prospects of increasing Scottish exports to the Provinces of Manitoba, Saskatchewan, Alberta, and British Columbia. Sir Alexander stated that special emphasis would be placed on the possibilities for Scottish engineering firms in the western Provinces. The mission will include Mr. H. Gardner, M.I.Mech.E., managing director of Glenfield and Kennedy, Ltd., Kilmarnock.

THE CASE FOR A FORTH ROAD BRIDGE.—That the industrial development of the East of Scotland would be handicapped for the next 50 years unless the Forth road bridge were built was suggested by Mr. George Veitch, President of the Edinburgh Chamber of Commerce, when he addressed the quarterly general meeting on July 17. The Chamber, he said, had taken a leading part in pressing for the building of the bridge, and were bitterly disappointed by the Government picture of the bridge's prospects during the next decade. Now was the time for action, while coal mining was developing and new factories were being erected.

NEW RUNWAY FOR PRESTWICK AIRPORT.—It was announced in the House of Commons on July 23 that the construction of a new subsidiary runway at Prestwick, which will make the airport "suitable for all existing types of civil aircraft in all wind conditions" is to begin next year, and should be completed by 1956. The runway will be 6,000 ft. long, with 500 ft. of prepared grass stopway running from the end of the main runway. There will be space to extend it to 8,000 ft. if necessary. The runway and taxi track will cost about 160,000*l*. A new control tower is also to be built.

M.S. "AORANGI" TO BE BROKEN UP.—The quadruple-screw motor vessel Aorangi, of 17,486 tons gross, arrived in the Clyde on July 24 on her final voyage to the shipbreaking yard of W. H. Arnott, Young & Co., Ltd., Dalmuir. Built by the Fairfield Shipbuilding and Engineering Co., Ltd., Glasgow, in 1924, she has the distinction of being the first large passenger and mail liner in the world to be driven by Diesel engines. Each of her four screws is driven by a six-cylinder Fairfield-Sulzer two-stroke single-acting air-injection engine. Particulars of the trials of these engines were given on page 376 of our 117th volume (1924). The Aorangi was built for the Union Steamship Company of New Zealand and subsequently transferred to the Canadian Australasian Line.

BRIQUETTING PLANT AT BRORA COLLIERY.—A new briquetting plant at Brora Colliery, Sutherlandshire—said to be the oldest working colliery in the British Commonwealth—is to be opened on October 1 by the Rt. Hon. Thomas Johnston, P.C., C.H., chairman of the North of Scotland Hydro-Electric Board. It will serve the northern counties, the nearest similar installation being at Alloa, in Clackmannanshire.

PROPOSED GRAVING DOCK FOR THE CLYDE.—Draft plans for a graving dock 1,200 ft. long, 160 ft. wide, and 47 ft. 11 in. deep, capable of accommodating the largest liners and warships, have been submitted to the Admiralty by Greenock Harbour Trust. It is estimated that the dock would take about three years to construct and would cost 3,000,000*l*. to 3,500,000*l*.

THE UNION CANAL.—A proposal in the Edinburgh city development plan to drain the Union Canal, fill in the channel, and use it as a road for fast traffic was strongly opposed by a section of business men at a meeting yesterday of Edinburgh Chamber of Commerce and Manufacturers. More than a dozen industrial concerns draw water from the canal. Mr. J. S. Marshall, chief engineer of the North British Rubber Company, said that his company drew about 90,000 gallons of cooling water an hour from the canal.

CLEVELAND AND THE NORTHERN COUNTIES.

LARGE DOXFORD ENGINE.—The Doxford engine to be installed in the 18,000-ton tanker Sheaf Royal, building on the Wear by J. L. Thompson and Sons, will be the biggest yet constructed at the Pallion Works of William Doxford & Sons, Ltd. It will have six cylinders 750 mm. in diameter with a combined stroke of 2,500 mm., and is to develop 7,750 brake horsepower at 103 r.p.m.

WATER-GAS PLANT FOR SUNDERLAND.—The Sunderland Division of the Northern Gas Board is to construct an automatic carburetted water-gas plant, with a capacity of 3,000,000 cub. ft. a day, at Hendon gasworks, Sunderland. A new ancillary plant, including ammonia recovery, and an electrostatic detarrer, is already in production at the works. A new gasholder of 250,000 cub. ft. capacity, being built at Washington, will be ready next year. The Gas Board are to construct a 12-in. high-pressure main from Ayres Quay to Fulwell Mill to improve gas pressure on the north side of the River Wear.

THREE COAL PITS TO BE CLOSED.—Three pits in North-West Durham are to be closed on August 22 by the Durham Divisional Coal Board, as they are no longer economic to operate. Three hundred men will be displaced, but 70 will be re-engaged for salvage work and at Hamsterley Colliery. Some of the remaining 230 will be offered work in the West Midlands. The pits concerned are the Bute and Tilley pits, and the Ruler Drift in the High Spen area. The Tilley drift was opened in 1949 and was stated then to have an expected life of 21 years. It is understood that, at a meeting of representatives of the National Coal Board and the National Union of Mineworkers, it was pointed out that, in 1949, the pits lost 64,000*l*., or 16*s*. a ton; in 1950, the loss was 68,000*l*., or 19*s*. a ton; in 1951, 59,000*l*., or 21*s*. a ton; and last year 90,000*l*., or 36*s*. a ton. It is understood that the miners did not accept these figures.

GREATHAM AIRPORT, WEST HARTLEPOOL.—A suggestion that local Councils on Tees-side should share with West Hartlepool Corporation the cost of maintaining Greatham Airport, West Hartlepool, has had a mixed reception. The airport is owned by the Corporation and, as it is not paying its way, they proposed to close it. So far, six members of the Council have approved the suggestion to share the cost, five are against it, three have deferred the question, and another is still considering it.

LANCASHIRE AND SOUTH YORKSHIRE.

STEEL MILL CLOSED.—Short-time working at the steelworks at Rotherham of J. J. Habershon and Sons, Limited, has been in operation for some few months in the hope that the closing of part of the plant might be avoided; but it has now been found necessary to close one hot mill, with some consequent unemployment and the dispersal of some employees to other departments.

LARGE CASTINGS FOR THE UNITED STATES.—Further progress has been made with the execution of the order from the United States for large steel castings, which has been in hand at the Grimesthorpe foundry of the English Steel Corporation since last August. The second of the castings, weighing 185 tons, left Sheffield on July 17 by road for Liverpool. Others of the same size, as well as smaller castings, are to follow at intervals. They are understood to be the largest steel castings that have ever left the country.

SAMUEL FOX & CO., LTD.—Excavation work is in progress for the new electric steel-melting plant to be installed at the works of Samuel Fox & Co., Ltd., Stocksbridge. The 60-ton electric-arc melting furnace will incorporate features considered to be an improvement upon the best American practice. The furnace will be the largest of its kind in the country, with an estimated output of 1,000 tons of steel a week.

THE MIDLANDS.

COURSES FOR INDUSTRIAL EXECUTIVES.—Birmingham University's new Institute for Engineering Production Studies, at Southfield, Norfolk-road, Edgbaston, Birmingham, 15, has now been opened. The Institute, which is in a building formerly occupied as a private house, has been established with an endowment of 54,000*l*. from the Birmingham firm of Joseph Lucas, Ltd. The first course to be held in the Institute is on "The Development of Work Study: Research and Practice," which ends on July 31. There is accommodation for 25 students in the building.

NEW DESIGN OF OMNIBUS.—The Birmingham and Midland Motor Omnibus Co., Ltd., are experimenting with a new design of single-deck omnibus having seating accommodation for 44 passengers. It weighs just under 5 tons unladen, and has hydraulically-operated disc brakes on all wheels, rubber suspension with independent suspension of the front wheels, and a disc transmission handbrake. The latter can be coupled to the wheel disc brakes if necessary. A prototype vehicle, fitted with the company's 8-litre engine, is now undergoing road tests.

CATHODE-RAY TUBE PRODUCTION AT SMETHWICK.—Chance Brothers, Ltd., Spon-lane, Smethwick, have announced that they are discontinuing the production of laboratory glassware, in order to concentrate on the manufacture of cathode-ray tubes. They have ascertained that there is sufficient capacity in the country to meet all requirements of the laboratory-glassware market, and are transferring their manufacturing capacity to cathode-ray tube production because of the greatly increased demand during the past few years.

SILTING OF BEVERE LOCK ON THE RIVER SEVERN.—Bevere Lock, on the river Severn, near Worcester, is subject to particularly heavy silting, the amount of material which must be dredged from the lock each year being as much as the total quantity taken from all the other four locks on the river. An investigation is now taking place into the problem, by means of a hydraulic model, at the newly-opened research station of the Docks and Inland Waterways Executive at Hayes, Middlesex. The laboratory is illustrated and described on page 138 of this issue. Bevere Lock passes a heavy oil-barge traffic on its way from Avonmouth to Stourport, and the need for improvement is acute.

"FLATTED" FACTORY IN WALSALL.—The first of the "flatted" factories planned for Walsall is now occupied. The Corporation of Walsall propose eventually to build six of these factories, which will be capable of housing any form of light industry, and manufacturers will be able to rent larger or smaller portions of the buildings according to their requirements. The first factory, which has a floor area of 12,714 sq. ft., has been taken by a single manufacturer on a lease of 28 years, with an option for a further 14 years.

SOUTH-WEST ENGLAND AND SOUTH WALES.

RESERVOIR SCHEME APPROVED.—Cardiff Corporation's scheme for the construction of a new reservoir at Blaentaf in the Brecon Beacons has been authorised by the Ministry of Housing and Local Government. It is estimated to cost 900,000*l*. Provisions relating to the diversion of a trunk road were excepted from the order. The new reservoir is designed to hold 900 million gallons.

SWANSEA DOCKS.—Plans for improving the entrance to Swansea docks are being considered by the Docks and Inland Waterways Executive. They were drawn up by a special committee of the Swansea Chamber of Commerce. Shipping interests at the port feel that an additional entrance is essential in the commercial and national interests, but suggest that, meanwhile, the present entrance might be made capable of handling more tonnage in the available time.

EFFECT OF HOLIDAYS ON COAL OUTPUT.—Coal output in South Wales and Monmouthshire is being curtailed by the staggering throughout the district of the miners' fortnights of paid summer holidays. This goes on until the end of August and, with the Bank holiday week-end ahead, the outlook is not promising. The effect on shipments to both home and foreign destinations is pronounced and the tonnage of coal loaded at the South Wales ports in the week ended July 7 was the lowest for some weeks. It totalled only 106,224 tons, which was 36,279 tons below the corresponding figure for last year.

GAS GRIDS IN WALES.—The rapid development of the gas-grid system throughout South Wales is expected to follow the completion of protracted negotiations by the Wales Gas Board for the supply of coke-oven gas. Mr. T. Mervyn Jones, chairman of the Board, said at a meeting of the Wales Gas Consultative Council that it was expected that the present daily supply of 6,000,000 cub. ft. of gas from the coke ovens of the Steel Company of Wales at Margam would be increased to 14,000,000 cub. ft. In addition, the Board hoped to supply gas to the Steel Company's new cold-reduction plant at Velindre. The grid system would eventually be extended to Milford Haven, Pembroke Dock, Haverfordwest and Tenby. In North Wales, the new Maelor Gasworks, near Wrexham, would be in production shortly, and if negotiations proved successful with John Summers & Co., Ltd., for a substantial supply of gas from their coke ovens at Shotton, the provision of a major grid scheme for North Wales would be accelerated.

THE APPROACH TO CARDIFF DOCKS.—The question of improving the entrance channel to Cardiff Docks remains under discussion by the Cardiff Port Development Association and the dock and town interests. The cost of carrying out a scientific investigation to ascertain whether a projected scheme of improvement, estimated to cost 1,000,000*l*., would prove a cure to the silting problem, is under examination.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*South-East London Branch:* Tuesday, August 4, 8 p.m., The Hall, Eltham Congregational Church, Court-road, Eltham. Various papers on "Contracting." *North-London Branch:* Wednesday, August 5, 7.45 p.m., Queen's Head Hotel, 677, Green-lanes, Harringay, N.4. "Safety Regulations," by Mr. A. Herwald.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Classification of Diamond Powder.—A new specification, B.S. No. 1987, constitutes another in the series for diamond tools for use in general engineering. It covers the classification of diamond powder in the sieve and sub-sieve ranges and has been prepared in order to provide a uniform method of specifying diamond powder. Clauses relating to composition, size ranges, impurities, method of sampling and of size measurement, and the marking of batches of powder are included. [Price 2*s.* 6*d.*, postage included.]

Swaged Cable-End Assemblies for Steel Wire Rope for Aircraft.—Two new specifications in the series of materials for aircraft, the first, B.S. No SP.53, covering swaged cable-end assemblies (B.A. and B.S.F. threads) for preformed steel wire rope, and the second, B.S. No. SP.54, concerned with similar assemblies but for preformed non-corrodible steel wire rope, have now been issued. The assemblies dealt with in SP.53 are suitable for use with British Standard W.9 wire rope, and those described in SP.54 are suitable for use with British Standard W.11 wire rope. The fittings comprising the assemblies and the turn-barrels and tension rods for use with them are those covered by specifications already included in the aircraft series, namely, Nos. SP.33 to 39 and SP.49 to 52. [Price of SP.53 6*s.*, and of SP.54 3*s.*, both postage included.]

Double-Coil Spring Washers for Aircraft.—Two further new specifications in the aircraft-series are published on a single leaflet. These, B.S. No. SP.55 and 56, relate to double-coil spring washers, the former covering steel washers and SP.56 phosphor-bronze washers. The materials, dimensions, properties and finish of washers suitable for use with bolts and nuts having B.A., B.S.F., and UNF. (Unified) threads are specified. The new specifications replace A.G.S. (Aircraft General Stores) specifications Nos. 163, 586, 1,583 (in part), and 1,607. [Price of the leaflet containing both specifications 1*s.*, postage included.]

SCHOLARSHIPS IN RUBBER TECHNOLOGY.—The British Tyre and Rubber Co., Ltd., Herga House, Vincent-square, London, S.W.1, have endowed a series of scholarships at the National College of Rubber Technology, of the Northern Polytechnic, Holloway-road, London, N.7. These will be known as B.T.R. Scholarships and will have an annual value of 300*l.* They will be tenable for three years and one scholarship will be awarded annually.

INSTITUTE OF MARINE ENGINEERS.—Forthcoming functions of the Institute of Marine Engineers, 85, The Minories, London, E.C.3, will include the annual conversazione at Grosvenor House, Park-lane, London, W.1, on Friday, December 4, 1953; the dinner of the Junior Section on Saturday, December 19, 1953; the annual dinner of the Institute at Grosvenor House on Friday, March 12, 1954; the annual general meeting of the Education Group at The Minories on Friday, March 19, 1954; and the annual general meeting of the Institute at The Minories on Tuesday, March 23, 1954.

"BOUNCING PUTTY."—A silicone, known as "Bouncing Putty" is now being marketed by Midland Silicones, Ltd., 19, Upper Brook-street, London, W.1. It is, as its name implies, a highly viscous rubber-like substance, which is easily shaped by kneading and pulling out slowly. It is, however, highly resistant to sudden stresses and shatters when subjected to blows. It rebounds when dropped. It is partly soluble in most organic solvents and in water. It has been employed in the United States for shock-absorbing, for damping vibration and also for transmitting ultrasonic waves.

CONTRACTS.

THE STEEL, PEECH AND TOZER BRANCH of the UNITED STEEL COMPANIES, LTD., Sheffield, have obtained an order for 5,500 tons of steel tyres for the Yugoslavian Railways. The value of the order is 800,000*l.* Two years ago the firm supplied 1,500 tons of locomotive and wagon tyres to the same administration.

DOBSON AND BARLOW, LTD., Bradley Fold Works, Bolton, Lancashire, have received an order from Etablissements Industriels pour la Soie et le Coton, S.A.E., spinners, of Cairo, for the supply of continuous rayon-spinning machinery, having an ultimate capacity for dealing with 7½ tons of rayon daily. It will be the first plant of this nature to be installed in Egypt, and is valued at 350,000*l.*

CHARLES BRAND AND SON, LTD., 25, Charles II-street, Haymarket, London, S.W.1, have received a contract from the Northern Ireland Ministry of Commerce for civil-engineering works at Kilkeel Harbour, County Down. These works are being undertaken on behalf of the Down County Council and represent the first stage of a scheme for the improvement of facilities at the harbour for fishing vessels. They include the deepening of the entrance channel and harbour mouth, and the strengthening and modification of piers at the harbour mouth. The contract is valued at 111,000*l.* and it is expected that the work will be completed in 18 months.

THE FRASER AND CHALMERS ENGINEERING WORKS of the GENERAL ELECTRIC CO., LTD., Magnet House, Kingsway, London, W.C.2, have secured a contract, through the firm's associates in Australia, the BRITISH GENERAL ELECTRIC CO. (PTY.), LTD., for a coal-preparation plant for installation at the Corrimal Colliery of the Corrimal Coal and Coke Pty., Ltd., Sydney, New South Wales. The plant is to have a capacity of 200 tons of coking coal an hour and the equipment to be supplied will include one Chance 10-ft. diameter cone with ancillary loading equipment, Sherwen electromagnetic screens, and Fraser and Chalmers shaker-type screens. In addition, a water-clarification plant will be supplied.

Orders recently placed by the North Eastern Region of British Railways include the reconstruction of the hot-ash pit at the motive-power depot, Hammerton-street, Bradford, with F. AND J. WATKINSON, 121, Fenby-avenue, Dudley-hill, Bradford; the extension of the wheel-tyring shop at the locomotive works, North-road, Darlington, with E. DAVIS (FIXERS), LTD., 20A, William-street, York; and the re-building of the North abutment and wing walls, and repairs to the brickwork of piers of bridge No. 185 at the Langley Moor Viaduct on the York and Newcastle branch, with WELLERMAN BROTHERS, LTD., Dun-street, Sheffield.

Contracts recently awarded by the Eastern Region of British Railways include the construction of a concrete watercourse, sewage pumping station, drainage system and fencing, in connection with the diversion of Loxford Water at Barking, Essex, with W. AND C. FRENCH, LTD., Buckhurst Hill, Essex; provision of a drainage system between Chelmsford and Hatfield Peveral, Essex, with TERSONS, LTD., 4, Dollis Park, London, N.3; and renewal of the drainage system and re-ballasting of the permanent way between Yaxley, Huntingdonshire, and Peterborough North, Northamptonshire, with TERSONS LTD.

NATIONAL OIL ENGINES (EXPORT), LTD., the export sales organisation of the National Gas and Oil Engine Co., Ltd., Ashton-under-Lyne, have obtained an order from the Inland Water Transport Department of the Government of Burma, for propulsion engines and auxiliary machinery for 56 creek-class single-screw motor vessels, for service in the Irrawaddy delta. National R4AM4 four-cylinder marine Diesel engines, developing 200 b.h.p. at 600 r.p.m., have been selected to provide the propulsive power. These engines have an oil-operated reverse-reduction gearbox with a ratio of 1·33, giving a propeller speed of 450 r.p.m., equal to 160 s.h.p., under service conditions in Burma. Each auxiliary set will comprise a Petter B2 two-cylinder Diesel engine, developing 18 b.h.p. at 1,500 r.p.m., and driving a Hamworthy compressor, an 8-kW generator, and a centrifugal pump. This contract is valued at 396,000*l.*

ELECTRICITY SUPPLY IN BELFAST.—During the year ended March 31, 1953, the total amount of electricity sold by the Belfast Corporation Electricity Department was 347·1 million kilowatt hours, a decrease of 0·2 per cent. compared with the previous year. This result is mainly ascribed to trade recession. On the other hand, the consumption for lighting alone increased by 7·03 per cent. and for domestic purposes by 0·69 per cent.

PERSONAL.

LORD ROCHDALE, O.B.E., T.D., has been nominated by the executive council for election as President of the National Union of Manufacturers, 6, Holborn Viaduct, London, E.C.1, in succession to SIR PATRICK HANNON, who recently decided not to accept re-election. MR. C. F. V. WILLIAMS, deputy director since 1951, was appointed to succeed SIR LEONARD BROWETT, K.C.B., C.B.E., as director. Sir Patrick has held the office of President since 1935, and Sir Leonard has been director since 1945.

SIR HAROLD WEST, Master Cutler, and managing director of Newton Chambers & Co., Ltd., Sheffield, has accepted the position of chairman of the board of governors of Loughborough College, Loughborough, at the invitation of Miss Florence Horsbrugh, C.B.E., the Minister of Education.

MAJOR NOEL E. WEBSTER, O.B.E., M.C., has been elected President of the Institution of Mining Engineers, 436, Salisbury House, Finsbury-circus, London, E.C.2, for the 1954-55 session. He will be installed, in succession to PROFESSOR J. CECIL MITCHESON, at the Institution's 60th annual general meeting, which will be held in London on Thursday, January 28, 1954.

MAJOR-GENERAL W. J. ELDRIDGE, C.B., C.B.E., D.S.O., has been appointed by the Minister of Supply to be Controller of Supplies (Munitions), in succession to GENERAL SIR KENNETH N. CRAWFORD, K.B.E., C.B., with effect from October 1, 1953. Major-General Eldridge will be granted the temporary rank of Lieutenant-General on assuming his new appointment.

SIR GILBERT DAVIS, Bt., A.M.I.Chem.E., and MR. E. W. YETTON, A.C.I.S., have been co-opted to the board of Eastwoods Ltd. Mr. Yetton vacates his position as secretary and assistant general manager of the company. MR. H. E. SEVERN, A.C.I.S., has been appointed secretary and MR. KENNETH MILLER, A.R.I.C.S., assistant general manager.

MR. E. GYLES, M.I.Mar.E., managing director, Plenty and Son, Ltd., Eagle Iron Works, Newbury, Berkshire, is retiring after nearly 50 years service with the company. He is being succeeded by MR. G. T. SHOOSMITH, M.A., M.I.C.E., M.I.Mech.E., M.I.Mar.E. MR. M. A. H. WALFORD, M.A., A.M.I. Mech.E., previously with Philips Electrical Ltd., London, has recently joined the firm.

MR. ROBERT S. DYBALL, having been appointed a director of Hills (West Bromwich), Ltd., Albion-road, West Bromwich, on July 17, in succession to the late MR. MANLEY COOPER, was elected chairman of the board on the same date.

MR. G. S. DANIELL, M.I.Mun.E., engineer and surveyor to the Stafford Rural District Council during the past three years, is leaving the Council's service at the end of August to take up a similar position with the Wokingham Rural District Council.

MR. A. O. BLUTH, a director of Erlangers, Ltd., and vice-chairman and joint managing director of the Jack Olding organisation, has been appointed a director of Vickers-Armstrongs Ltd., Vickers House, Broadway, London, S.W.1.

MR. JOHN AYRES, managing director of Petters, Ltd., Staines, Middlesex, has been released from his service agreements with the BRUSH GROUP, to enable him to accept the positions of general manager and director of Simms Motor Units, Ltd., Oak-lane, London, N.2, on October 1, next. CAPTAIN R. C. PETTER, who is a director of the Brush Electrical Engineering Co., Ltd., Loughborough, has accepted the appointment of managing director of Petters, Ltd., as from that date, on a temporary basis.

MR. K. P. WOOD, M.A. (Cantab.), has resigned from the board of James Beresford and Son, Ltd., Birmingham, as from July 22, and is no longer connected with the company, which he joined as sales manager in 1933. He became a director in 1945.

MR. J. A. THOMSON, a director of Caledonia Investments, Ltd., has joined the board of Macrome, Ltd., Aldersley, Wolverhampton.

MR. C. L. GUEST, chief industrial engineer to the Dunlop Rubber Co., Ltd., St. James's House, St. James's-street, London, S.W.1, has retired after 36 years in the company's service. Mr. Guest served in various positions at Fort Dunlop, Birmingham, was subsequently appointed chief efficiency engineer at St. James's House, and became chief industrial engineer in 1950.

BRITISH INSULATED CALLENDER'S CABLES LTD. announce that, with effect from August 1, the address of their Exeter branch will be changed to 40, Whipton Village-road, Whipton, Exeter. (Telephone: Exeter 67308.)

AMPLION (1932) LTD., 230, Tottenham Court-road, London, W.1, have been appointed by the Plessey Co., Ltd., Ilford, Essex, as distributors to the wholesale and retail trades for the sale of the firm's radio and television components.

AIRCRAFT TEST-HOUSE AND RESEARCH LABORATORIES.

HANDLEY PAGE, LIMITED, LONDON.

(*For Description, see Page* 150.)

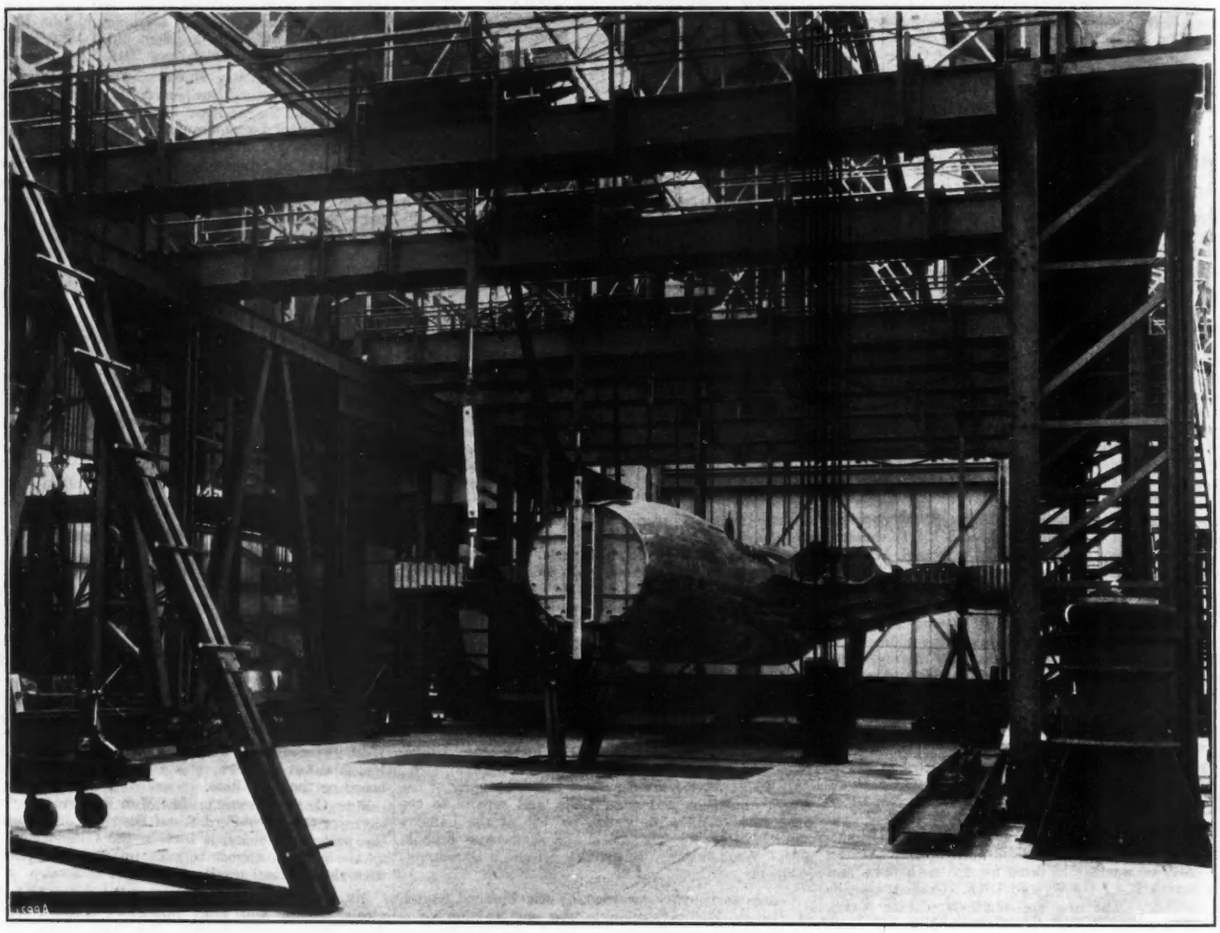


FIG. 1. STRUCTURAL TEST FRAME, WITH "VICTOR" FUSELAGE UNDER TEST.

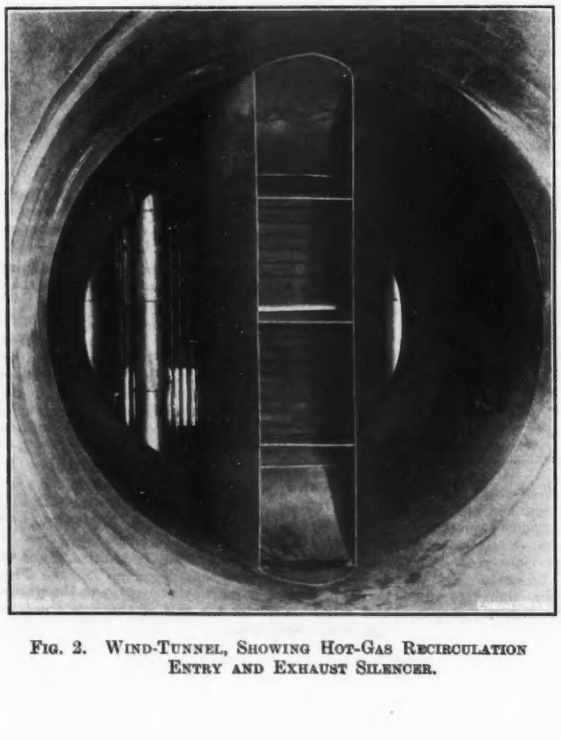


FIG. 2. WIND-TUNNEL, SHOWING HOT-GAS RECIRCULATION ENTRY AND EXHAUST SILENCER.

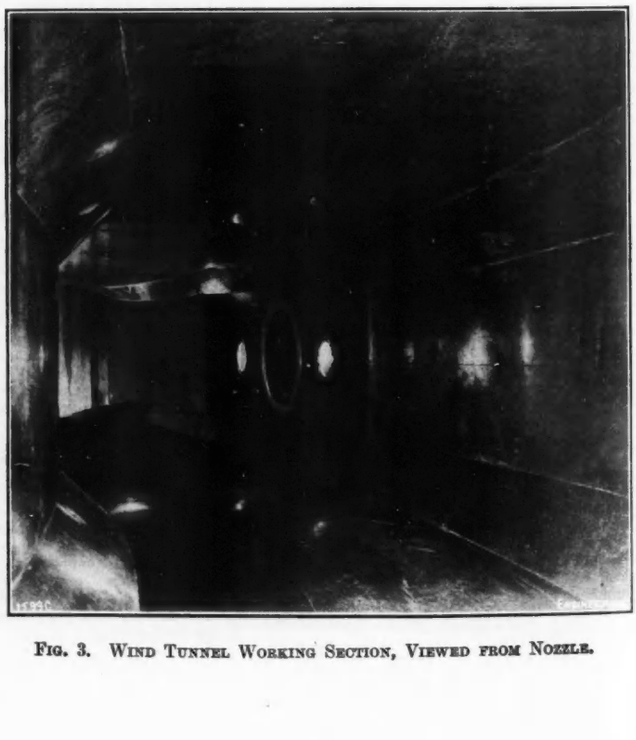


FIG. 3. WIND TUNNEL WORKING SECTION, VIEWED FROM NOZZLE.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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ENGINEERING, LESQUARE, LONDON.

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TEMPLE BAR 3663 and 3664.

All editorial correspondence should be addressed to the Editor and all other correspondence to the Manager.

Accounts are payable to ENGINEERING Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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ENGINEERING may be ordered from any newsagent in town or country and from railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

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For Canada	£5 5 0

Subscriptions for periods less than twelve months are based on the price of a single copy, namely, 2*s.* 3*d.* post free.

ADVERTISEMENT RATES.

Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

INDEX TO VOL. 174.

The Index to Vol. 174 of ENGINEERING (July-December, 1952) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

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ENGINEERING

FRIDAY, JULY 31, 1953.

VOL. 176. No. 4566.

PROBLEMS OF ATMOSPHERIC POLLUTION.

THE Government has set up a committee "to examine the nature, causes and effects of air pollution and the efficacy of present preventive measures; to consider what further preventive measures are practicable; and to make recommendations." The immediate reason for this action appears to be the attention which was directed to the effect on public health of a serious fog in London last winter. The matter has been discussed by some Members of Parliament and others in terms which suggest that the question of air pollution has been neglected in the past and that it is time that some action was taken. Actually, the investigation of air pollution has been carried on continuously since at least as long ago as 1912, when a voluntary committee was formed as a result of a suggestion made by the late Dr. J. S. Owens, who did so much work on the early development of dust counters, deposit gauges and other instruments. The work of this voluntary committee was later taken over by the Department of Scientific and Industrial Research which has been dealing with the subject for some twenty years.

The matter is now handled by the Atmospheric Pollution Research Committee of the Fuel Research Board. The measurement, analysis and, if possible, elimination of polluting matter in the atmosphere are scientific problems and all the members of this committee have scientific qualifications. The new Government committee is not lacking in members of corresponding status and three of the number are also members of the Fuel Research Board committee. There are other representatives of applied science and two concerned with public health. It is in this latter field that the committee may possibly be able to make useful contributions towards the solution of what is a grave problem. For the scientific aspects of the subject it may be expected to rely to a major extent on the work of the Fuel Research Committee. There would be no purpose in repeating experimental work carried out, and re-collecting data amassed, over many years.

Great Britain is an industrial country and must remain so if it is to prosper. Many, or most, of the activities on which its economy is based involve the combustion of fuel, and the problems of atmospheric pollution are never likely to be solved completely. Much, however, can be done, and has been done, towards mitigating them. Some twenty years ago, it was estimated that smoke produced by domestic fires in London was more than twice that attributable to industrial furnaces. The great extension of gas and electric heating in domestic premises has done something to improve this state of affairs, but domestic smoke is still a major contributor to air pollution in built-up areas. Many new types of solid-fuel grates and stoves have been introduced and the latest report* of the Fuel Research Board states that the sale of such improved types has increased enormously. This is no doubt partly due to their installation in new houses. Landlords are hardly likely to fit them in old houses, still let at pre-war rents. Professor F. E. Simon has suggested that they should be given away, but that is hardly a likely development.

The section of the Fuel Research Board report dealing with domestic heating is largely concerned with efficiency tests of grates and stoves, and smoke is an undesired by-product of low efficiency. Almost the whole of the report has direct, or indirect, relation to atmospheric pollution. An example of direct relation is furnished by the investigations concerned with the removal of sulphur compounds from flue gas. This matter has two aspects, both of which are of importance. Sulphur compounds are a particularly undesirable constituent in polluted air but, in addition, sulphur is a valuable material, and the report states that "the longer-term trend is in the direction of a permanent world shortage." In these circumstances, if sulphur can be recovered from flue gas in useful form, two important ends are served. It is estimated that two million tons of sulphur in the form of acid oxides are discharged each year into the atmosphere from the combustion of coal and coke, and further, "as mining proceeds, there is a tendency, particularly in some coalfields, for coals to be increasingly rich in some constituents, for example, sulphur."

Full-scale plants are in operation at Battersea and Fulham generating stations for the removal of sulphur compounds from the flue gas, but the sulphur is not recovered as a product of value and the system in use involves a cost equivalent to 7*s.* to 10*s.* for every ton of coal burnt under the boilers. It is stated in the report that the most promising alternative method of dealing with the matter is provided by the Fulham-Simon Carves process, in which sulphur is removed from the flue gas by means of crude concentrated ammonia liquor, which is produced as a by-product at many gasworks.

A Fulham-Simon Carves plant, designed to deal with 25,000 cub. ft. of flue gas per hour, has been under test at the Fuel Research Station. Efficiencies of removal of oxides of sulphur from flue gas varying

* *Report of the Fuel Research Board with the Report of the Director of Fuel Research for the Year* 1952. H.M. Stationery Office. [Price 2*s.* 6*d.* net.]

from 90 to 94 per cent. were obtained, the actual figure being determined by the flue-gas and liquor-circulation rates. The main purpose of this plant may be taken to be the elimination of sulphur compounds from the atmosphere, but the secondary purpose, the recovery of sulphur, may ultimately prove to be of first-class importance. Recovery is in the form of ammonium sulphate, with some elemental sulphur. Preliminary estimates indicate that this method of treating flue gas is likely to be less costly than other methods now in operation on a large scale. It is recommended that a much larger pilot plant should be built in order to obtain design and cost data for full-scale operation. It is added that "this is a question mainly for the British Electricity Authority."

The elimination of smoke and other polluting matter from gases discharged to the atmosphere is naturally but one item in the wide range of work in progress at the Fuel Research Station, but one other item bearing on it may be mentioned. This is a series of tests carried out on a Cochran boiler fitted with a smoke-eliminating fire door, of a type which has been so successful with Lancashire boilers. The conclusion come to was that although the device resulted in some improvement this was not sufficient to make up for the increased complication in design. Other boiler work has been concerned with scale-formation problems. Investigations on this subject have been carried on in conjunction with the Boiler Availability Committee. As is generally known, scaling troubles have been most pronounced with stoker-fired boilers, but as there is a tendency "for coals to be increasingly rich in some constituents, such as sulphur," more attention is now being paid to the formation of deposits in boilers fired with pulverised coal.

Experimental work of much engineering interest has continued on the problem of using solid fuel in gas turbines. Earlier reports of the Fuel Research Board have described the vortex and straight-through combustion chambers which have been developed. Work has continued with both of these and promising results have been obtained with a modified form of the straight-through chamber. A plant has been designed for installation at the National Gas Turbine Establishment. Improvements in the vortex chamber have increased the efficiency of combustion to 94 per cent., the carbon in the ejected ash being reduced to 38 per cent. A major problem in this field of work is the cleaning of the hot gases before they are led to the turbine in order to prevent excessive erosion and the reduction of aerodynamic efficiency. Two proprietary dust-extraction units constructed of heat-resisting steel have been installed at the station in connection with the investigation of this matter.

A considerable part of the report is concerned with coal blending. The reserves of the best coking coals are estimated to be only about 6 per cent. of the total national coal reserves and in view of the importance of special-quality cokes in the metallurgical industries, it is very desirable that these good-coking coals should be conserved, as far as possible, by blending them with coals which are inferior from the point of view of coke production. Work carried out during the year has shown that satisfactory metallurgical coke can be made from a blend of first-class Durham coking coal with as much as 50 per cent. of weakly-coking Northumberland coal. Other work bearing on coal conservation has been directed to the utilisation of coal of small size and low grade for the production of fuel gas. The experimental "cyclone" generator in which the ash is removed as a molten slag has been under test with coal below ¼ in. in size, and trials are to be made with coke breeze. Air supplied to the generator is enriched with oxygen. Results are reasonably promising but the practical and economic possibilities of the system cannot yet be assessed.

COAL IN EUROPE.

IN spite of the great expansion in oil-refining capacity in Europe during recent years—and, indeed, in oil production, which is being actively developed—coal remains a major factor in European industry and economics; not less so because of the regrettable shrinkage in British coal exports since the second World War. The production and consumption of coal in European countries, therefore, have been subjects of close study by the Organisation for European Economic Co-operation—more familiarly known as "O.E.E.C."—which has recently published a report, by its Coal Committee, on "The Coal Position in Europe in 1952 and 1953." In this report, the progress in production is compared with current trends in consumption and, on the basis of estimates prepared in the various countries concerned, some indication is given of the main problems that may be expected to arise. Finally, some suggestions are made to enable the several countries to cope with those problems.

In April, 1952, it was estimated that the European production for that year would be increased to 479·6 million tons—representing 15·6 million tons over the 1951 total—to which the United Kingdom was expected to contribute 229·4 millions, the German Federal Republic 126 millions, France 57·4 millions, Belgium 31 millions, Holland 12·8 millions, the Saar 17 millions, and Turkey, Italy and various other countries a total of 6 millions. In fact, however, the combined production amounted to only 475·1 million tons, although the returns of the five principal producers all showed increases as compared with 1951. On the other hand, the output of coke-oven coke, which is so important in its effect upon steel production, was 82·3 million tons in 1952, compared with 75·3 millions in 1951 and an estimated production for 1952 of 81·9 millions. It may be noted that, while several countries (including the United Kingdom) reported considerable rises in the numbers of miners employed, this is now being represented as a reason for falling output, on the ground that the presence of a larger number of inexperienced men requires the employment of more skilled men on "the unproductive preparatory work of opening up the coal face." There is probably a good deal of substance in this contention, especially in its application to the more highly mechanised mining industries such as that of the United Kingdom, for the moving and re-erection of coal-cutting and conveying machinery is very much a skilled operation. Moreover, the proportion of young recruits to the industry has risen appreciably. Only 15,000 young men entered it in 1950, but there were 20,000 in 1951 and 26,000 in 1952. It is of interest that, among men aged 21 to 30, the number leaving the industry was about 30 per cent. less in 1952 than in the previous year, which is encouraging; but absenteeism is still high—about 12 per cent.

American coal is still being imported into Europe in considerable quantities, involving a dollar expenditure which, if it could have been diverted to investment to promote greater productivity, might well have rendered the imports unnecessary; assuming, of course, that the coal-getting personnel in the several countries are able and willing to use all possible appliances to the utmost. Germany took the largest quantity of American coal in 1952—7·4 million tons out of a total of 20·2 millions; but it is pointed out that one reason why German coal production in 1952 fell short of the estimated amount by 2·7 million tons was the impossibility of raising the necessary funds to finance the desired investment programme. The rapid recovery of German industry as a whole, which has been commented upon by many observers, suggests that this disability is likely to be overcome in the near future; but, as the steel industry is one of those which are making the greatest progress, it may be that imports of coal from the United States will have to be continued for a longer time than the German coal output, considered by itself, might indicate as probable, in order to maintain the necessary supplies of coking coal.

As mentioned above, the 1952 estimate of the production in 1953 was 479·6 million tons; but this has now been revised to a total of 487·2 millions. In part, this is expected to result from increased mechanisation and from the steady progress that is being made in modernising the equipment of the older pits, but it is expected that an appreciable improvement in output will occur because the recruits of 1952 are now in a fair way to becoming skilled miners. If this expectation is realised, the figures of output should show a still greater improvement in 1954, as it is remarked that, "in most countries, the workers are no longer reluctant to enter the mines." With regard to the United Kingdom, however, it is pointed out that the revised estimate of 235 million tons may be on the high side because of the difficulty of predicting the losses due to longer holidays.

The estimated consumption of coal in Europe in 1953 is between 497·3 and 499·3 million tons, in which the share of the United Kingdom (212 million tons) is by far the largest item, Germany coming second with 127·4 million tons. The deficit—16·9 to 18·9 million tons—will have to be met by imports from the United States and from "Poland and other sources"; but whereas, in 1952, these imports were 20·2 and 7·1 million tons, respectively, it is expected that, in 1953, the respective proportions will be 8·9 to 10·9 millions and 8 millions, which should ease considerably the pressure on European available dollar resources. The imports from America would consist mainly of coking coal.

It is considered that the main coal problems with which European countries will be confronted in 1953 will fall into four main categories; namely, obtaining higher output, the surplus production of certain types of coal and the question of stocks, questions of qualities, and the organisation of the coal market. Recruitment, it is thought, will present no special difficulties, though the training of the recruits may do so. The maintenance of individual productivity, however, may prove difficult unless the effect of modernisation and of increased mechanisation keeps pace with the problems resulting from the need to work in deeper and dirtier coal measures. To overcome the difficulty of balancing consumption against the production of particular kinds of coal, it is proposed that a joint storage policy for producers and consumers should be adopted, so that coal stocks might be more evenly spread; when pithead stocks accumulate unduly, production may have to be reduced because of the difficulty of storing more coal in restricted space.

The supply of European anthracite, it is pointed out, has always been less than the demand, and "the level of reserves gives no hope of any substantial increase in output," so that "it is only by increasing availabilities of coke and by developing techniques for the production of semi-coke that the problem of supplies for household use can be at least partially solved." The principal recommendations, therefore, are that efforts should be made to develop coking processes for high-volatile coal and, wherever possible, to substitute such coal in processes which, at present, require the use of coking coal; to develop the coal-mixing and grinding equipment in existing coking plants so that coking fines may be partly replaced by coal of other types and grades; and to restrict the tonnage of bituminous coal, used by consumers other than coking plants, to their essential requirements.

NOTES.

THE ROYAL SOCIETY AND NUFFIELD FOUNDATION COMMONWEALTH BURSARIES.

THE Royal Society announce that, to fill a need with respect to Commonwealth scientific relations, they and the Nuffield Foundation have jointly decided to initiate a Commonwealth Bursaries scheme. The Nuffield Foundation is supporting this scheme as a complement to its established programme of Commonwealth fellowships and other awards. The purpose of the new scheme, it is stated, is "to provide facilities for increasing the efficiency of investigators of proven worth by enabling them to pursue research, learn techniques or follow other forms of study where either or both the physical and personal environment overseas in the Commonwealth is peculiarly favourable." The main difference between these bursaries and ordinary research fellowships is not merely one of duration but of emphasis, as the bursaries will aim not so much at obtaining the answer to a particular question as at improving the powers of the recipient to extend the bounds of knowledge. The scheme will be operated for an experimental period of five years. During this time, the Nuffield Foundation will provide 5,000*l.* a year which will be devoted to bursaries to United Kingdom scientists who wish to go to oversea parts of the Commonwealth, and to scientists of one oversea part of the Commonwealth who wish to go to another. Initially, the Royal Society will also make a contribution of 2,500*l.*, which will be available for movement in any direction within the Commonwealth, including to the United Kingdom. It is hoped that funds may be obtained from other sources, particularly from overseas, to make possible the full development of the scheme, especially by increasing the proportion of bursaries available for scientists of oversea countries of the Commonwealth who desire facilities in the United Kingdom. Each bursary will provide for the cost of travel and also for maintenance, normally for periods of two to twelve months. The applicant must be sponsored by a recognised research authority and must produce evidence that he or she has prior permission to work in the laboratory or other scientific institution chosen. It is expected that, in the operation of the scheme, Fellows of the Royal Society throughout the Commonwealth will assist in sponsoring and assessing applicants for bursaries. A joint Royal Society and Nuffield Foundation Commonwealth Bursaries Committee, under the chairmanship of Sir Edward Salisbury, C.B.E., secretary of the Royal Society, has been set up to administer the scheme. Of the other members, Mr. Leslie Farrer-Brown, Sir John Stopford, F.R.S., and Professor A. R. Todd, F.R.S., have been nominated by the trustees of the Nuffield Foundation; and Professor G. R. Cameron, F.R.S., Professor H. S. W. Massey, F.R.S., and Sir Eric Rideal, F.R.S., by the Council of the Royal Society. Dr. D. C. Martin, assistant secretary of the Royal Society, will act as secretary to the Committee. It is proposed initially to consider applications at intervals of six months, beginning early in 1954. Application forms and further details will be obtainable from the assistant secretary of the Royal Society, Burlington House, Piccadilly, London, W.1. Applications must be submitted not later than March 15 and September 15 in each year.

THE FUTURE OF WOOLWICH ARSENAL.

On July 17, the Minister of Supply (Mr. Duncan Sandys, M.P.) visited Woolwich Arsenal to judge for himself the possibilities of the site for other purposes; and on July 27, in reply to a question in the House of Commons, he stated that he was considering the proposals placed before him in the report of the Inter-Departmental Committee, which, he thought, represented "a constructive effort to find a workable solution to the long-standing problems of Woolwich Arsenal." They would have the effect, over a period of time, of reducing the number of Government employees on the Arsenal site from about 14,000 to about 10,500; but the introduction of a trading estate, which was one of the proposals, should ultimately result in an appreciable increase in the total number of persons employed there. He thought it right, however, before taking any final decisions, to afford to the workpeople, the public authorities, and others concerned, a full opportunity to study the plan and to comment upon it. "Any such observations," said the Minister, "should be submitted to me not later than October 31." In addition to the suggestion of a trading estate of 100 acres, the main proposals were that the filling factory should be closed and its site made available for other purposes; that the existing gun and ammunition factories should be amalgamated into a single Royal Ordnance Factory, to be used mainly for experimental and development work; that the rest of the space made available by that re-organisation should be at the disposal of the Service Departments, to enable them to concentrate their various engineering workshops, stores, etc., and to bring to the Arsenal "certain activities from elsewhere"; and that, at the eastern end of the site, arrangements should be made for controlled tipping, to raise the ground above river level.

ANALYSERS AND COMPUTERS FOR ELECTRICAL SYSTEMS.

A vacation school, the object of which was to encourage the wider use by electrical engineers of analysers and computers for solving problems in electrical machines, control systems and networks, was held in the Electrical Engineering Department of the Imperial College of Science and Technology, London, from Monday, July 13, to Friday, July 17. In the first lecture Mr. B. Adkins discussed electrical machine problems, which he grouped into design and performance calculations. In a subsequent lecture Dr. J. R. Mortlock introduced some of the more common problems encountered in the design of power systems, indicating the types of equations met with in each and the usual methods of solving them. The next section of the course was opened by Dr. W. J. Gibbs with a lecture on the mathematics of the problems, during which he reviewed the types of calculation often required and demonstrated that matrices can assist the orderly arrangement and manipulation of performance equations of all types of systems. In a further lecture on "Systematic Computations," Mr. M. I. Humphrey Davies put forward suggestions for processes intermediate between simple slide rule calculations and the complex methods used in automatic computers and described an improved type of semi-automatic machine, which has been constructed at the Imperial College for handling two-dimensional quantities. Dr. J. M. Bennett described several types of automatic digital computer and discussed their advantages for dealing rapidly and accurately with many engineering problems. A survey of analogue computers was given by Mr. L. Gosland, while the final lecture, by Dr. G. R. Slemon, was concerned with the solution of non-linear problems.

THE PROFESSIONAL CLASSES AID COUNCIL.

The 32nd annual report of the Professional Classes Aid Council, which has now been published, covering the twelve months to March 31, 1953, expresses some concern at the increasing calls upon the funds available for relief, which obliged the Council to refuse a number of the less pressing applications submitted to them. Even so, a total of 13,245*l.* was expended—888*l.* more than in the previous year. The result was a deficit of some 1,192*l.*, which was reduced to 192*l.* by drawing 1,000*l.* from "a substantial gift" made by an anonymous donor in the year 1949-50. The new applications numbered 557, which was 115 more than in 1951-52. In dealing with these, the Council followed their usual practice of referring the applicants to other professional funds, where such reference was practicable. Fifty-three new cases were accepted for financial aid, making a total of 275 families who were receiving help. Much of the available income is devoted to educating and training the children of professional parents who are unable to face that expense unaided, and the grants for this purpose during the year amounted to 3,914*l.* The secretary of the Council is Miss P. Roden, 20, Campden Hill-square, London, W.8.

LETTERS TO THE EDITOR.

THE CALCULATION OF COMPRESSIBLE FLOW THROUGH A VENTURI METER.

TO THE EDITOR OF ENGINEERING.

SIR,—The ideal discharge of a gas through a Venturi meter is customarily written in a form such as

$$W = \frac{p_1 A_2}{\sqrt{RT_1}} \sqrt{\frac{2 g \gamma p^{\frac{2}{\gamma}}}{\gamma - 1} \left(\frac{1 - p^{\frac{\gamma-1}{\gamma}}}{1 - p^{\frac{2}{\gamma}} m^2} \right)}. \quad (1)$$

in which

W is the mass flow,

A_1, A_2 represent the cross-sectional areas upstream and at the throat,

P_1, P_2 represent the absolute pressures upstream and at the throat,

$m = \frac{A_2}{A_1}$ represents the area ratio,

$p = \frac{P_2}{P_1}$ represents the pressure ratio,

γ represents the ratio of specific heats of the gas,

R represents the gas content, and

T_1 represents the ambient temperature upstream.

Ignoring the effect of compressibility, the ideal discharge is

$$W^1 = \frac{p_1 A_2}{\sqrt{R T_1}} \sqrt{\frac{2 g (1 - p)}{1 - m^2}},$$

so that the discharge is reduced by virtue of compressibility in the ratio

$$\varepsilon \equiv \frac{W}{W^1} = \sqrt{\frac{\gamma p^{\frac{2}{\gamma}}}{\gamma - 1} \left(\frac{1 - p^{\frac{\gamma-1}{\gamma}}}{1 - p} \right) \left(\frac{1 - m^2}{1 - p^{\frac{2}{\gamma}} m^2} \right)}. \quad (2)$$

If the value of p is close to unity, the numerator and denominator of the first term within brackets each represent the small difference between nearly equal numbers, and a much more convenient form for slide-rule computation is found as follows. Writing, for convenience, $(1 - \alpha) \equiv p$ and expanding (2) in ascending powers of α, we obtain

$$\varepsilon = \sqrt{\frac{\left(1 - \frac{3\alpha}{2\gamma}\right)(1 - m^2)}{1 - \left(1 - \frac{2\alpha}{\gamma}\right) m^2}}, \quad . \quad (3)$$

as a first approximation. This expression is easy to use, and, when $\gamma = 1{\cdot}40$, is in error by not more than 0·2 per cent. for values of m lying between zero and 0·6 and values of p lying between 0·85 and unity.

A closer approximation, in which powers up to α^2 are retained, is

$$\varepsilon = \sqrt{\frac{\left[1 - \frac{3\alpha}{2\gamma} + \frac{\alpha^2}{6\gamma^2}(7 - 5\gamma)\right](1 - m^2)}{1 - \left[1 - \frac{2\alpha}{\gamma} + \frac{\alpha^2}{\gamma^2}(2 - \gamma)\right] m^2}}. \quad (4)$$

Yours faithfully,

E. MARKLAND.

University of Nottingham.
July 16, 1953.

THE COST OF AUTOMATIC TRAIN CONTROL.

TO THE EDITOR OF ENGINEERING.

SIR,—In the leading article published in your issue of July 10, dealing with the cost of automatic train control, you say that this Federation in its campaign for greater road expenditure suffered from the disadvantage that it represents "the views of road interests." You may not know that

the membership of the Federation consists of 106 national organisations representing some quarter of a million individual firms and businesses in a very wide variety of trades and industries. While the Federation does represent organisations concerned with the construction of roads, the manufacture of vehicles and fuel, a much greater proportion of the Federation's membership represents trades and industries generally, which are concerned with road transport because it is an essential element in their activity. Indeed, road transport is part of the process of production and cannot be divorced from it. Your editorial, we feel, cannot fail to increase the realisation of the need for greater expenditure on roads.

Yours faithfully,
M. FRANCIS,
Information Officer.

British Road Federation, Limited,
4a, Bloomsbury-square,
W.C.1.
July 13, 1953.

THE CORNISH ENGINES PRESERVATION SOCIETY.

TO THE EDITOR OF ENGINEERING.

SIR,—Final arrangements are now in hand for a ceremony of great interest to the engineering world which will take place at the Camborne Engineering Museum on Saturday, September 12, 1953, when Lord Falmouth, the President of the Cornish Engines Preservation Society, will formally present to the Society the 22-in. Rostowrack rotary Cornish engine which was formerly used for combined pumping and winding in one of his china-clay pits. The engine has been removed and re-erected in the museum opposite Richard Trevithick's statue in Camborne. This engine was built in Cornwall in 1851, and continued in service to about 1951: it has now been overhauled and erected in perfect keeping with normal early Nineteenth Century Cornish mine-engineering practice.

The above ceremony will be preceded by another interesting event at 2.30 p.m., when Captain R. E. Trevithick, M.I.C.E., a great-grandson of the famous Cornish engineer, Richard Trevithick, will unveil a commemorative plaque on the cottage at Penponds which was the home of the pioneer of high-pressure steam and "Father of the Locomotive."

The Cornish Engines Preservation Society have made commendable progress in their purpose of forming a "National Trevithick Site Museum," which should go far to make Cornwall a Mecca for the engineer and all interested in industrial history. The Society now possess other properties, including a 90-in. Cornish pumping engine, still at work on East Pool mine; a 30-in. rotative Cornish beam winding engine, at the same mine; and a 24-in. beam winder at the famous Levant mine, which was built and erected in 1840. They hope to be associated in the future in the preservation of the 80-in. Cornish pumping engine at Robinson's Shaft, South Crofty tin mine. This engine was built at Hayle in 1854, and is still at work; within a year, it will have completed a century of useful activity.

Yours faithfully,
W. TREGONING HOOPER,
Honorary Secretary.

Trevannanse-road,
St. Agnes, Cornwall.
July 17, 1953.

PLASTIC SHEETING.—Bakelite Ltd., 12-18, Grosvenor-gardens, London, S.W.1, have published a 15-page booklet entitled *Vybak—Rigid Sheet*. It deals with sheets made from vinyl chloride-acetate and polyvinyl-chloride resins which are produced in a range of thicknesses and in a variety of colours and surface finishes. The booklet is divided into five sections the first of which carries the same title as the booklet and describes the properties of the material; it also gives tables of the commercial sizes and forms in which it is produced. The other four sections are entitled "Machining," "Forming," "Cementing" and "Finishing and Finishes," and these processes are all described in detail with the help of a number of explanatory illustrations.

OBITUARY.

SIR JOHNSTONE WRIGHT.

As briefly noted in our last week's issue, Sir Johnstone Wright died at Bramley, Surrey, on Sunday, July 19, at the age of 70. He was a well-known figure in the electricity supply industry and had played a prominent part in the construction, and subsequently the operation, of the 132-kV transmission system of the Central Electricity Board.

Johnstone Wright was born at Dunning, Perthshire, on January 22, 1883, and was educated at Perth Academy. He served his apprenticeship with Messrs. D. Stewart and Company, Glasgow from 1898 to 1903, during which period he also attended evening classes at the Glasgow Technical College. From December, 1903, to March, 1905, he was testing engineer and supervisor of outside contracts with the British Electric Plant Company,

THE LATE SIR JOHNSTONE WRIGHT.

Limited, Alloa, while in May of the latter year he began his long connection with the electricity supply industry by being appointed chief assistant engineer at the Oban Electricity Works. He joined the Cleveland and Durham Electric Power Company in December, 1906, as charge engineer at the Grangetown power station and for the next 13 years was engaged with that undertaking in various positions. Among other activities he acted as clerk of the works for the construction of the Newport power station, of which he afterwards became superintendent; and was also engaged, under the chief construction and operating engineer, on the erection of a number of waste-heat stations and extensions to others. During the last 18 months of his service with the company he acted as power station superintendent and in this position was responsible for the operation and maintenance of nine stations in the Tees area.

In 1919, Johnstone Wright became deputy city electrical engineer at Bradford under the late Mr. Thomas Roles, while in 1922 he was appointed chief engineer and manager of the Belfast electricity department, where he remained until he joined the newly-formed Central Electricity Board in 1927, as deputy chief engineer to Mr. (afterwards Sir Archibald) Page. This body, it may be recalled, was required by the provisions of the Electricity (Supply) Act, 1926, to construct the transmission lines and transformer stations necessary to connect a number of "selected" power stations. The provisions of this measure were far from palatable to certain sections of the industry, and while the Board had compulsory powers, it was decided by those concerned that full use of them would be unwise. In the event, persuasion and tact, in the exercise of which Johnstone Wright played his part, proved efficacious in most cases; and had the advantage of leaving no residuum of ill feeling.

Moreover, the exercise of these qualities led to no increase in the time required for construction. In fact, within the short space of five years it was possible to bring a network, consisting of 4,430 miles of transmission line, 3,039 miles of which operated at 132 kV, into use with a minimum of friction, and to inaugurate a scheme of generation which enabled the plant available to be utilised at the highest efficiency and considerably reduced the amount of spare equipment it was necessary to install. The work involved in this development was described in detail in a paper read before the Institution of Electrical Engineers on "The Construction of the 'Grid' Transmission System in Great Britain," of which Johnstone Wright and Mr. C. W. Marshall were co-authors and for which they were awarded an Institution premium. While the correctness of the policy laid down in the Electricity (Supply) Act, 1926, was amply demonstrated before the war, it more than proved its worth between 1939 and 1945 and the developments which are now taking place at 275 kV are a further tribute to its soundness.

In 1933, Johnstone Wright became chief engineer of the Central Electricity Board in succession to Sir Archibald Page, who had been appointed general manager, while, in 1944, he was promoted to be general manager and, for about twelve months before his retirement in 1948, acted as chairman. He then joined the board of British Insulated Callender's Cables, Limited, and when the British Insulated Callender's Construction Company was formed in 1949 he became deputy chairman, a position from which he retired in 1952.

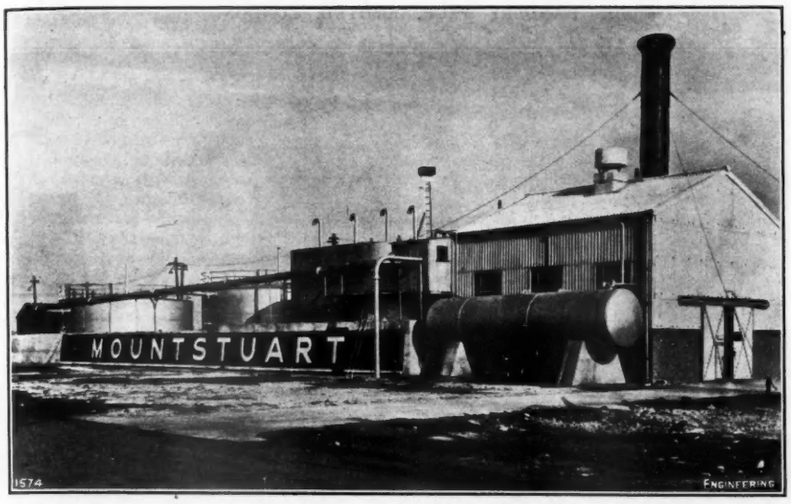
Sir Johnstone received the honour of knighthood in 1943. His connection with the Institution of Electrical Engineers began in 1911 when he was elected an associate member. He was transferred to the class of member in 1919 and after serving on the Council and as vice-president, was elected president in 1939. In his presidential address he summarised the experiences gained from the operation of the grid and the progress made from an engineering and national standpoint since 1926. He had also been a Member of the Institution of Civil Engineers since 1934 and of the Fuel Research Board from 1944-47. In addition to the papers we have mentioned, he made several other contributions to the proceedings of the Institution of Electrical Engineers.

ENGINEER-CAPTAIN W. ONYON, M.V.O., R.N.

BY the death, on July 19, of Engineer-Captain William Onyon, M.V.O., R.N. (ret.), marine engineering, both naval and mercantile, has lost one of its most colourful personalities; for Captain Onyon, who entered the Royal Navy at a time when some, at least, of the older capital ships still carried square rig as auxiliary to their steam reciprocating propelling machinery, was the first chief engineer of the famous Dreadnought, the first turbine-driven battleship, and was closely associated also with the design and construction of H.M.S. Argus, one of the earliest aircraft-carriers.

Captain Onyon was born at Belvedere, Kent, on June 24, 1862, and so was in his 92nd year at the time of his death. He was educated at Christ's Hospital, which was then in Newgate-street, London, and, on joining the Navy in 1878, in H.M.S. Marlborough, for many years the engineer students' training ship at Portsmouth. Later, he attended the Royal Naval College at Greenwich, which he left at the end of 1884 on appointment to H.M.S. Monarch, an ironclad turret ship. Subsequently, he served in H.M. ships Ajax, Alexandra, Thunderer and Agamemnon before being transferred in 1891, for a short period, to the engineering department at the Admiralty. From September, 1891, to the end of 1894, he was the engineer officer

TANK-CLEANING PLANT FOR OIL TANKERS.



in charge of the hulls and machinery of the flotillas of torpedo boats based on Malta. After this, he was then sent to the shipyard of Messrs. Yarrow and Company at Poplar, as engineer overseer for the destroyers Dasher and Hasty. He served for a time at sea in both these vessels before being appointed, in November, 1898, manager of the engineering department at H.M. Dockyard, Jamaica, where he was stationed until the beginning of 1902. During the next three years he was engaged, after short periods in H.M.S. Excellent, on gun mountings, and H.M.S. Vernon, on torpedo work, as engineer overseer for the Clyde district.

In July, 1905, by which time he had become an engineer commander, Onyon was appointed chief engineer of H.M.S. Dreadnought, then building at Portsmouth, and engineer overseer on the construction of her steam-turbine machinery at the Turbinia Works of the Parsons Marine Steam Turbine Company, Wallsend-on-Tyne. He remained in this pioneer warship for three years, gaining experience in the use of steam turbines which made it almost inevitable that his next appointment should be to the Engineer-in-Chief's department at the Admralty, since the decision had been taken that all new warships should have steam-turbine machinery. He was promoted to engineer-captain in June, 1911, and almost immediately was appointed to H.M.S. Medina, the P. and O. liner chartered to take King George V and Queen Mary to India for the Durbar at Delhi. For this service, he was made a Member of the Royal Victorian Order. He continued at sea as Staff Engineer of the First Battle-Cruiser Squadron, under Rear-Admiral (afterwards Sir) Lewis Bayly, his last ship being H.M.S. Lion. At that time, he was the senior naval engineer officer to be serving afloat. He retired from the Navy in January, 1913.

Immediately after his retirement, Captain Onyon was appointed engineering manager at the Dalmuir shipyard of William Beardmore and Company Limited, where he remained for 12 years, during which time he was responsible for the construction of machinery for a large number of warships and merchant vessels. Among them were the Italian liners Conte Rosso, Conte Verde and Conte Biancamano, and also H.M.S. Argus, originally designed as a liner for the Lloyd Sabaudo line, of Genoa, which was acquired by the Admiralty and converted to an aircraft carrier. She was notable for having a completely flush flight-deck, the boiler flue-gases being discharged astern through horizontal ducts. In 1926, Captain Onyon was transferred to the London office of Messrs. Beardmore, where he remained until the Dalmuir shipyard was closed. Subsequently, he was retained in a consultative capacity by Messrs. Vickers-Armstrongs Limited, and was also associated with the Perfecta Tube Company, Limited. Eventually, he retired to Plymstock, Devon, where he lived for the rest of his life.

Captain Onyon had been a member of the Institution of Naval Architects since 1910 and served on the Council from 1926 to 1933. He was also a member of the Institution of Civil Engineers, and a past-President of the Institute of Marine Engineers, to whom he delivered, in 1927, a presidential address in which he expressed strong views on the status of engineer officers in the Navy, as exemplified by the Fleet Order of 1925, which had deprived them of military rank. It was the subject of a leading article in our issue of September 16, 1927 (vol. 124, page 363). During the period that he spent at Dalmuir, he was a member of Council, and eventually a vice-president, of the Institution of Engineers and Shipbuilders in Scotland; and for a number of years he was a member, and an active supporter, of the Institute of Metals.

THE NORTH-EAST ENGINEERING BUREAU.—The North-East Engineering Bureau, Newcastle-on-Tyne, which was formed after the war to help in the expansion of light engineering industry or the North-East Coast, has been merged with the Northern Region of the Engineering Industries' Association. Mr. P. R. Walton, who has been general manager of the Bureau for the past five years, has been appointed general secretary of the joint organisation, with offices at 109, Pilgrim-street, Newcastle.

HIGH-VOLTAGE RELAY FOR AERIAL CIRCUITS.—A two-pole change-over relay, which has been primarily designed for aerial switching but has other applications, is now being manufactured by Electro Methods, Ltd., Caxton-way, Stevenage, Hertfordshire. As a new insulating material is used in its construction and the contacts are widely spaced, the breakdown voltage between the contacts and the moving blades is 3,000 volts, between the moving blades themselves 14,000 volts and between the closed contacts and the frame 7,000 volts. The operating time is 13 milliseconds. The relay will operate on either alternating or direct-current standard voltages.

RADIO CONTROL OF HIGH-SPEED AIRCRAFT.—The pilotless aircraft which was launched recently at the Woomera rocket range is a high-speed jet-propelled machine and can be controlled either from the ground or from another aircraft. To enable this to be done, radio equipment consisting of several small units, which can be stowed in various places in the aircraft, has been developed by the General Electric Co., Ltd., Kingsway, London, W.C.2, to the technical requirements of the Ministry of Supply. These units require no "setting up" when installed and can be used by unskilled personnel to direct the machine almost as accurately as could a human pilot. They are hermetically sealed and will work continuously at temperatures between 130 deg. and — 70 deg. F. in a vacuum or in water. The equipment can be shaken 150 times a second without impairing operation, and adjustment is unaffected by valve replacement or wide variations in battery voltage.

TANK-CLEANING PLANT AT CARDIFF DOCKS.

A NEW plant for cleaning out the tanks of oil tankers has recently been laid down at Roath Dock, Cardiff, for Mountstuart Dry Docks, Limited; tankers up to 31,000 tons deadweight can be accommodated. The plant, which has been designed by the company, is intended to clean-out the tanks and to free them from gas in two or three days whereas it has formerly been necessary for the tanker to proceed to sea for six to eight days to be flushed out. Furthermore, it was this cleaning-out at sea which has been largely responsible for the fouling of beaches and it is to be hoped that use of the new plant will help to overcome this difficulty. The new plant, shown in the accompanying illustration, is completely self-contained and comprises a boiler house, an oil separator, filters and reclaimed-oil storage tanks.

The tankers are washed out by the Butterworth system, in which hot water, at 175 lb. per square inch and at temperatures between 155 deg. and 185 deg. F., is sprayed into the tanks through mechanically operated nozzles. These nozzles, which are introduced into the tanks through ports, otherwise sealed by a plate, can be moved vertically through the depth of the tank and simultaneously rotated so that all sides of the tank are subjected to the washing action. By this system it is unnecessary for men to enter the gas-laden atmosphere of a recently emptied tank. The oily ballast and cleanings are then pumped ashore by the tanker's own oil-discharging plant, through the separator and the filters; the reclaimed oil is put into the storage tanks and the surplus water discharged into the dock.

In the new dockside plant, the separator is totally enclosed in a steel casing and both it and the oil-storage tanks are protected from the possibility of fire by introducing an inert gas into the space between the oil surface and the tank ceiling. The composition of this gas, accurately maintained, is as follows: nitrogen, 84 per cent.; carbon dioxide, 15 per cent.; oxygen and carbon monoxide together make up the remaining 1 per cent. This gas is generated in a machine made by W. C. Holmes and Company, Limited, Whitestone Iron Works, Huddersfield. The gas is made by the controlled combustion, under pressure, of fuel oil, the end products being brought to atmospheric temperature in a compact water cooler. The particular generator just installed at Cardiff has an output of 15,000 cub. ft. of gas per hour, measured at atmospheric temperature and pressure; this quantity of gas is produced from 10·7 gallons of fuel oil and, to cool it, requires the passage of about 1,500 gallons of cooling water per hour. The gas can be compressed for storage and may be pumped without dissociation. The fire precautions are completed by close compliance with the requirements of the Home Office and, in particular, embody all the recommendations that were made following the investigations into the explosion and fire at the Avonmouth oil depot in 1951; these have led to the installation of a comprehensive system of foam generation and distribution in the boiler house as well as to the tanks.

DIRECTORY OF SOURCES OF SPECIALISED INFORMATION.—Organisations acting as sources of specialised information and wishing to be included in the *Aslib Directory*, a revised edition of which is now being prepared, are invited to write to the Director of Aslib, 4, Palace-gate, London, W.8, as soon as possible.

TEST PLANT FOR PROPELLER-TURBINE ENGINES.—A contract for two test plants for Armstrong Siddeley Double Mamba propeller-turbine engines has been placed by the Admiralty with Heenan and Froude, Ltd., Worcester, to be installed at one of the Royal Navy aircraft repair establishments. The engine on test will be mounted on a dummy wing extending across the width of the test house. The tests will be remotely controlled from a sound-proofed chamber fitted with an observation window. All controls, piping, etc., will be incorporated in the wing structure. The contract also includes the supply of an accessory fuel-storage system, an oil-priming truck, control-room heating, and control-room and engine-room lighting.

AIRCRAFT TEST-HOUSE AND RESEARCH LABORATORIES.

On Tuesday, June 21, a new aircraft test-house and high-speed wind tunnel providing comprehensive research and development facilities at the Radlett airfield of Handley Page, Limited, Cricklewood, London, N.W.2, was opened by Mr. A. R. W. Low, Parliamentary Secretary to the Minister of Supply.

The test house, part of which is illustrated in Fig. 1, on page 144, provides facilities for research in new structural forms and for carrying out all the structural tests and investigations on airframe services which are essential to the development of large high-speed aircraft. The building provides a 36-ft. clearance over a floor area of 30,000 sq. ft. One side of the test-house is backed by a two-storey block of offices and laboratories. The main structural test frame, designed by the company, is designed to apply a maximum load of 400 tons, and is 50 per cent. wider and higher than the large Cathedral test rig at the Royal Aircraft Establishment, Farnborough; the length, 126 ft., is the same. (A description of the Cathedral rig was given on page 717 of our 169th volume (1950).) Fig 1 shows part of the Handley Page Victor bomber-aeroplane fuselage set up in the rig.

The main load-reacting structure of the test frame, which provides a number of reaction points each capable of taking a 30,000-lb. load, is buried in the concrete floor, thus giving unobstructed floor space under the loading bridge and providing easy access for inspecting the structures under test. The loads are applied by hydraulic straining units, electrically controlled. A separate hydraulic system provides for measuring the applied loads, and strain-gauge measurements on the components under test can be recorded on 800 channels. A smaller frame, of similar design, is used for testing tail units, etc.

In one corner of the test-house, the floor is strengthened, and stanchions and overhead tackle are provided for structural tests on seats, castings, doors, and other small components. Work of this type can also be carried out on a large L-frame, with loads of up to 20 tons. The test-house is also equipped with two Avery universal testing machines of 15 tons and 50 tons capacity, and a Handley-Page 200-ton test machine for compression tests on structural panels. Fatigue-testing equipment includes a Losenhausen machine, with a load range of up to 300 tons static or 150 tons fluctuating; a Krouse-type machine of Handley Page design with a load range from 1,000 to 5,000 tons; and an Amsler Vibrophore machine for loads up to 4,000 lb. A water tank, 42 ft. long and 14 ft. in width and depth, can be used for pressure-tests on fuselages.

The test-house building also includes well-equipped photographic, electronic, chemical and instrument laboratories. Much of the measuring equipment used in the tests is designed in the electronics department; for example, the apparatus used for resonance-testing the prototype Victor aircraft, and the balance and control gear for the high-speed wind tunnel. The chemical laboratory is concerned with metallurgical research and investigation of structural techniques, such as spot-welding and synthetic-resin bonding.

The new high-speed wind tunnel at Radlett, which is of the induced-flow type, has been designed by the company in collaboration with Rolls-Royce, Limited, who were primarily responsible for the injector layout and for testing a $\frac{1}{7}$th-scale model to check the performance of the tunnel. Assistance in the design was also received from the Ministry of Supply, the Royal Aircraft Establishment and the National Physical Laboratory.

The tunnel is driven by three Rolls-Royce Nene jet engines each developing 5,000 lb. static thrust, the jets of which form the primary flow of the injector. An airflow induced by the injector passes through the tunnel working section, illustrated in Fig. 3, on page 144, where, in the absence of a model, it is accelerated to the speed of sound. The engines are outside the tunnel, mounted vertically one above the other and staggered in

AIRCRAFT TEST-HOUSE AND LABORATORIES.

HANDLEY PAGE, LIMITED, LONDON.

FIG. 4. WIND-TUNNEL CONTROL DESK.

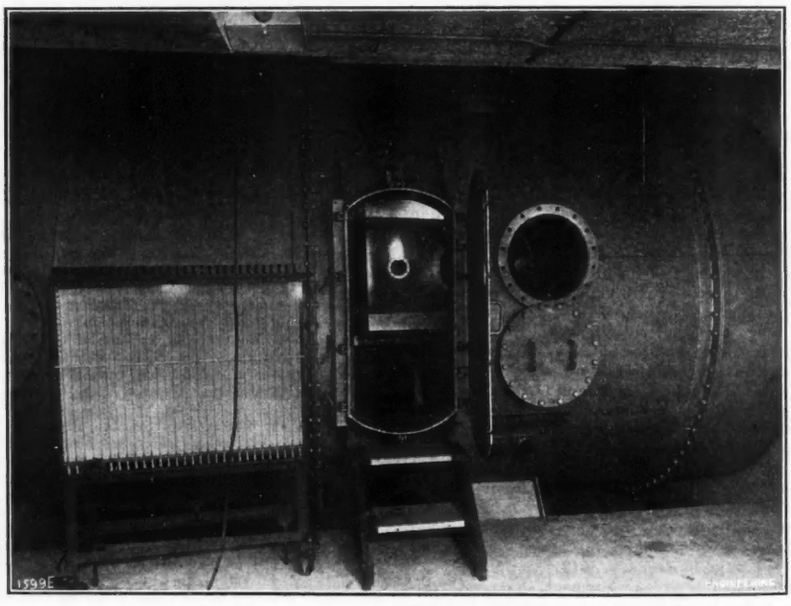


FIG. 5. PRESSURE CELL SHOWING ENTRANCE TO WORKING SECTION.

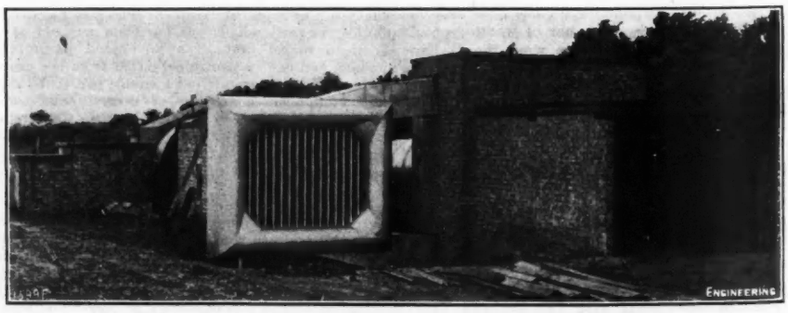


FIG. 6. WIND-TUNNEL INTAKE AND EXHAUST SILENCER.

elevation. Only the jet pipes enter the tunnel duct system; thus, the engines can be readily inspected even when the tunnel is in operation, and there is no risk of damage to the engines in the event of a model breaking away from its supports. Combustion air enters the engine house through two banks of absorbent splitters.

The incoming air enters the tunnel between a set of 15 hollow aerofoils of 4-ft. chord and 3 in. thick, as may be seen in Fig. 6, opposite, which also shows the exhaust silencer. To avoid condensation in the working section, the air is mixed with part of the tunnel exhaust which is circulated through the hollow aerofoils. Internal vanes ensure that the hot air is distributed evenly into the tunnel intake through the open trailing edges of the aerofoils. The amount of re-circulation through the tunnel is controlled by valves.

The nozzle, working section, and transition of the diffuser are mounted inside a pressure cell, as shown in Fig. 5, opposite, to which they are vented, thus reducing the loading on their sides. A settling chamber, 30 ft. long, lies between the heater aerofoils and the nozzle, which has a 12-to-1 contraction ratio. The octagonal working section is 8 ft. long and 4 ft. by 3 ft. in cross section; boundary-layer growth is compensated by varying the fillet section.

Between the entry to the working section and the end of the diffuser, the duct remains parallel in width; only the depth is varied. Beyond the working section, a transition piece blends it into the main diffuser. At the end of the diffuser, the duct turns through 90 deg. with a high aspect-ratio bend, followed by a transition section of approximately constant area. After turning back through a second 90-deg. bend, the three engine jet pipes enter the tunnel duct. The latter then changes from rectangular to circular cross-section with a constant area over a length of 40 ft. Beyond this point, the circular cross-sectional area increases towards the exit. The tunnel exhaust silencer consists of two banks of absorbent splitters in a rectangular duct. Ahead of the silencer is the hot-gas recirculation entry, illustrated in Fig. 2, on page 144, which comprises an aerofoil with an open leading edge spanning the duct from roof to floor. The trunking leading the hot gases to the entry is fitted with cascades of aerofoils at each 90-deg. bend.

The engine-control room is alongside the engine house and is provided with double windows through which the engines can be observed. There is a telephone link between the control room and the observation room, which surrounds the tunnel working section, and is illustrated in Fig. 4, opposite. It contains the six-component tunnel balance and all the essential test equipment.

FAIREY "ROTODYNE" HELICOPTER.—The Ministry of Supply have placed an order with the Fairey Aviation Co., Ltd., Hayes, Middlesex, for the construction of a 40 to 50-seat helicopter, the Rotodyne, for research purposes. It will be powered by two Napier Eland propeller turbines, and will employ a jet-driven rotor blade-tip drive. The layout will provide large loading doors at the tail end of the fuselage, and a variety of possible cabin layouts will be available.

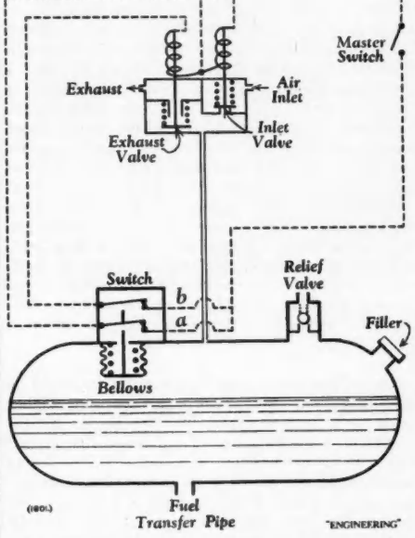
EUROPEAN TELEVISION CONFERENCE.—As a result of the successful relaying of the Coronation television broadcasts to France, Holland and Western Germany, a conference was held at Broadcasting House this week to consider future developments. The principal subjects discussed were a proposal for the exchange of television programmes during the Christmas season and plans for setting up permanent links between the countries concerned. A number of technical matters were also dealt with.

ELECTRICITY SUPPLY STATISTICS.—During June, 1953, 4,197 million kWh were sold by the British Electricity Authority to the Area Boards, an increase of 11·5 per cent. over the output in the same month of last year. When corrected for the weather and the number of working days the increase was, however, 9·3 per cent., the weather having been slightly colder and there having been more effective working days. The amount of electricity sent out by the Area Boards was also 4,197 million kWh (some supplies are obtained from other sources than the Central Authority), compared with 3,764 million kWh in the corresponding month of 1952. Supplies to "mainly industrial" areas increased by 9·7 per cent. and to "mainly non-industrial" areas by 13·2 per cent.

ELECTRO-PNEUMATIC FUEL TRANSFER SYSTEM.

THE diagram herewith illustrates an electro-pneumatic method devised by the Aviation Division of the Dunlop Rubber Company to transfer fuel from the auxiliary tanks to the main tanks of an aircraft. Apart from its simplicity and light weight, it has the advantage that pressure need only be applied to the tanks while the transfer of fuel is in progress. The operating air supply may be at any pressure up to 3,000 lb. per square inch, which can be reduced to as little as 3 lb. or 4 lb. per square inch by means of a single air valve and a pressure-actuated switch.

The pressure-valve assembly contains an inlet valve and an exhaust valve, both operated by solenoids and so connected that, when the current is switched off, the inlet valve is closed and the exhaust is open. The combined inlet and exhaust valve system is connected by a direct pipeline to the fuel tank. On the top of the tank is mounted the pressure-actuated switch, containing two pairs of



quick make-and-break contacts; and inside the tank, beneath the switch, is attached a sealed spring-loaded bellows, sensitive to the pressure in the tank. Mounted on the baseplate of the bellows, and protruding upward through the wall of the tank, is a plunger which, if it rises, pushes up the arm of the contacts *a*.

When fuel is to be transferred, the pilot closes the master switch, thereby energising the pressure-valve solenoids. The exhaust valve closes and the inlet valve opens, allowing air pressure to pass to the tank. Increasing pressure in the tank compresses the bellows until, at the required tank pressure, the plunger touches the arm of the contacts *a*, breaking the circuit to the inlet-valve solenoid, when the valve closes under the action of its return spring. During the transfer of fuel, the bellows expands slightly as the tank pressure tends to drop. This expansion withdraws the operating plunger, and the contacts *a* then close, re-energising the inlet-valve solenoid and opening the valve to admit more air. The bellows then contract, breaking the circuit again, and will continue to breathe in this manner throughout the transfer of fuel, so maintaining the pressure in the tank at the required level.

If, due to a rise of temperature or any other cause, there is a rise of pressure in the tank above that required for fuel transfer, a further compression of the bellows will occur, causing a greater movement in the arm of the switch contacts *a*. The small plunger attached to this arm will force up the arm of the contacts *b* and de-energise the exhaust-valve solenoid, thus opening the exhaust valve to permit the excess pressure to escape.

FORTHCOMING EXHIBITIONS AND CONFERENCES.

THIS list appears in the last issue of each month. Organisers are invited to send to the Editor particulars of forthcoming events.

EXHIBITION OF HISTORIC BOOKS ON MACHINES.—Friday, May 1, to Sunday, August 30, at the Science Museum, South Kensington, London, S.W.7. (Telephone: KENsington 6371.) See also our issue of May 15, 1953, page 623.

"LONDON ON WHEELS" EXHIBITION.—Wednesday, May 20, to Saturday, August 29. At the Shareholders' Meeting Room, Euston Station, London, N.W.1. Organised by the British Transport Commission, 55, Broadway, London, S.W.1. (Telephone: ABBey 5666.) See also our issue of May 29, 1953, page 691.

"SHELL AND THE GAS TURBINE" EXHIBITION.—Wednesday, June 3, to Monday, August 31, in the public enclosure, Northolt Airport. Organised by the Shell Petroleum Co., Ltd., St. Helen's-court, Great St. Helen's, London, E.C.3. (Telephone: AVEnue 4321.)

SUMMER SCHOOL FOR YOUNG EXECUTIVES ON PRODUCTIVITY METHODS.—Monday, July 27, to Saturday, August 22, at Worcester College, Oxford. Additional information available from Mr. Alan Kimber, Sidney-Barton, Ltd., 7, Ludgate Broadway, London, E.C.4. (Telephone: CITy 5391); or from Mr. John Ayres, Petters, Ltd., Staines, Middlesex. (Telephone: Staines 1122.) See also page 121, *ante*.

THIRD INTERNATIONAL CONFERENCE ON SOIL MECHANICS AND FOUNDATION ENGINEERING.—Sunday, August 16, to Tuesday, August 25, at Zürich and Lausanne. Apply to the secretary, Société Internationale de Mécanique des Sols et des Travaux de Fondations, Gloriastrasse 37, Zürich 44.

RADIO AND TELEVISION EXHIBITION.—Saturday, August 29, to Sunday, September 6, at Düsseldorf. *Agents:* John E. Buck and Co., 47, Brewer-street, London, W.1. (Telephone: GERrard 7576.)

NATIONAL RADIO SHOW.—Tuesday, September 1, to Saturday, September 12, at Earl's Court, London, S.W.5. Applications to the organisers, Radio Industries Council, 59, Russell-square, London, W.C.1. (Telephone: MUSeum 6901.)

BRITISH ASSOCIATION.—Wednesday, September 2, to Wednesday, September 9, at Liverpool. Applications to be made to the joint local secretaries: Mr. T. Alker, Municipal Buildings, Dale-street, Liverpool, 2. (Telephone: Central 8433); and Mr. S. Dumbell, O.B.E., University of Liverpool, Brownlow Hill, Liverpool, 3. (Telephone: Royal 6022.) See also our issue of February 13, 1953, page 214.

BUILDING PLANT EXHIBITION.—Thursday, September 3, to Wednesday, September 9, on the Goose Fair site at Nottingham. Organised by the Ministry of Works, Lambeth Bridge House, Albert-embankment, London, S.E.1. (Telephone: RELiance 7611.)

19TH ENGINEERING, MARINE AND WELDING EXHIBITION AND CHEMICAL PLANT EXHIBITION.—Thursday, September 3, to Thursday, September 17, at Olympia, London, W.14. Apply to F. W. Bridges & Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. (Telephone: WHItehall 0568.)

STUDENTS' PRODUCTION ENGINEERING CONVENTION.—Saturday, September 5, at Birmingham University. Organised by the Institution of Production Engineers. Apply to Mr. T. Houghton, 86, Crompton-road, Handsworth, Birmingham, 20. See also page 77, *ante*.

VIENNA INTERNATIONAL TRADE FAIR.—Sunday, September 6, to Sunday, September 13, at Vienna. *Agents:* The British-Austrian Chamber of Commerce, 29, Dorset-square, London, N.W.1. (Telephone: PADdington 7646.)

AMERICAN CHEMICAL SOCIETY: 124TH NATIONAL MEETING.—Sunday, September 6, to Friday, September 11, at Chicago, Illinois. Apply to the secretary, American Chemical Society, 1155, 16th-street, Washington 6, D.C., U.S.A.

FORESTRY AND THE TIMBER INDUSTRIES CONGRESS.—Monday, September 7, to Saturday, September 12, at Stuttgart, Germany. Held under the auspices of the Organisation for European Economic Co-operation and the Mutual Security Agency. Apply to the secretary of the congress, Mr. Eberhard von Bernuth, Luisenstrasse 33, Bonn, Germany. See also our issue of May 22, 1953, page 664.

CHEMICAL ENGINEERING CONFERENCE.—Monday, September 7, to Friday, September 11, at Olympia, London, W.14. Organised by the Chemical Engineering Group and the Institution of Chemical Engineers, 56, Victoria-street, Westminster, London, S.W.1. (Telephone: VICtoria 6161.) See also page 21, *ante*.

FLYING DISPLAY AND EXHIBITION, FARNBOROUGH.—Monday, September 7, to Sunday, September 13, at Farnborough, Hampshire. Organised by the Society of

British Aircraft Constructors, Ltd., 32, Savile-row, London, W.1. (Telephone: REGent 5215.)

WELSH INDUSTRIES FAIR.—Wednesday, September 9, to Saturday, September 19, at the New Pavilion, Sophia Gardens, Cardiff. Further particulars obtainable from the organisers, the National Industrial Development Council of Wales and Monmouthshire, 17, Windsor-place, Cardiff. (Telephone: Cardiff 23049.)

INSTITUTION OF NAVAL ARCHITECTS AUTUMN MEETING.—Monday, September 14, to Friday, September 18, at Scheveningen, Holland. Apply to the secretary of the Institution, 10, Upper Belgrave-street, Westminster, London, S.W.1. (Telephone: SLOane 4622.) See also our issue of May 29, 1953, page 703.

FOURTH ANGLO-AMERICAN AERONAUTICAL CONFERENCE.—Monday, September 14, to Thursday, September 17, in London. Communications to the secretary, Royal Aeronautical Society, 4, Hamilton-place, London, W.1. (Telephone: GROsvenor 3515.) See also our issue of May 29, 1953, page 678.

PUBLIC LIGHTING CONFERENCE AND EXHIBITION.—Tuesday, September 15, to Friday, September 18, at Liverpool. Arranged by the Association of Public Lighting Engineers, 22, Surrey-street, London, W.C.2. (Telephone: TEMple Bar 9607.)

SECOND NATIONAL HANDICRAFTS AND HOBBIES EXHIBITION.—Thursday, September 17, to Wednesday, September 30, at the Central Hall, Westminster, London, S.W.1. Organised by Henderson Exhibitions, Ltd., 74, Holland Park, London, W.11. (Telephone: PARk 7360.)

CONGRESS OF THE INTERNATIONAL SCIENTIFIC FILM ASSOCIATION.—Friday, September 18, to Sunday, September 27, at the Royal Festival Hall and the National Film Theatre, London, S.E.1. Organised by the Scientific Film Association, 164, Shaftesbury-avenue, London, W.C.2. (Telephone: TEMple Bar 4694.) See also our issue of June 5, 1953, page 706.

EIGHTH NATIONAL INSTRUMENT EXHIBIT.—Monday, September 21, to Friday, September 25, at the Sherman Hotel, Chicago. Organised by the Instrument Society of America, 921, Ridge-avenue, Pittsburgh 12, Pennsylvania, U.S.A.

CONFERENCE ON INDUSTRIAL APPLICATIONS OF STATISTICS.—Friday, September 25, to Sunday, September 27, at the College of Aeronautics, Cranfield, Bedfordshire. Organised by the Royal Statistical Society, 4, Portugal-street, London, W.C.2. (Telephone: HOLborn 4283.) See also our issue of May 29, 1953, page 685.

IRON AND STEEL INSTITUTE SPECIAL MEETING.—Wednesday, September 30, to Wednesday, October 7, in the Netherlands. Further information obtainable from the secretary, the Iron and Steel Institute, 4, Grosvenor-gardens, Westminster, London, S.W.1. (Telephone: SLOane 0061.) See also page 111, *ante*.

AMERICAN SOCIETY OF AUTOMOTIVE ENGINEERS: NATIONAL AERONAUTICAL MEETING, AIRCRAFT ENGINEERING DISPLAY AND AIRCRAFT PRODUCTION FORUM.—Wednesday, October 7, to Saturday, October 10, at Los Angeles, California. Apply to the secretary of the Society, 29, West 39th-street, New York 18, U.S.A.

FIFTH INTERNATIONAL MECHANICAL ENGINEERING CONGRESS.—Friday, October 9, to Thursday, October 15, at Turin. Organised by the Associazione Industriali Metallurgici Meccanici Affini, Via Massena 20, Turin. Applications to be sent to the director, British Engineers' Association, 32, Victoria-street, London, S.W.1. (Telephone: ABBey 2141.) See also page 63, *ante*.

ENGINEERING INDUSTRIES ASSOCIATION: LONDON REGIONAL DISPLAY.—Tuesday, Wednesday and Thursday, October 13, 14 and 15, at the Horticultural Hall, Vincent-square, London, S.W.1. Apply to the secretary of the Association, 9, Seymour-street, Portman-square, London, W.1. (Telephone: WELbeck 2241.)

INTERNATIONAL TEXTILE MACHINERY AND ACCESSORIES EXHIBITION.—Wednesday, October 14, to Saturday, October 24, at Belle Vue, Manchester. Organised by the Textile Recorder Machinery and Accessories Exhibitions, Ltd., Old Colony House, South King-street, Manchester, 2. (Telephone: Blackfriars 7234-6.)

INTERNATIONAL MOTOR SHOW.—Wednesday, October 21, to Saturday, October 31, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148, Piccadilly, London, W.1. (Telephone: GROsvenor 4040.)

SCOTTISH MOTOR SHOW.—Friday, November 13, to Saturday, November 21, at Kelvin Hall, Glasgow. Apply to the Scottish Motor Trades Association, Ltd., 3, Palmerston-place, Edinburgh, 12. (Telephone: Central 3643.)

CYCLE AND MOTOR CYCLE SHOW.—Saturday, November 14, to Saturday, November 21, at Earl's Court, London, S.W.5. Organised by the British Cycle and Motor Cycle Manufacturers' and Traders' Union, The Towers, Warwick-road, Coventry. (Telephone: Coventry 62511.)

LABOUR NOTES.

DEMANDS by the engineering unions, for an increase of three shillings in the pound in the wages of their members, were formally presented by officials of the Confederation of Shipbuilding and Engineering Unions to representatives of the Engineering and Allied Employers' National Federation on July 21, as briefly reported in our last issue. The claims apply to all grades of adult male employees in the engineering and associated industries, both time and piecework operatives, and are for a 15 per cent. increase on the consolidated rates, "the amounts accruing to be added to earnings." These claims involve an increase of about 1*l.* a week in the wages of skilled men, and of approximately 17*s.* 6*d.* a week in those of unskilled staffs, but the precise sums payable would vary according to the district concerned. If granted in full, the claims would increase the amount paid out by the engineering group of industries in wages, by about 125 million pounds a year.

The 38 unions affiliated to the Confederation are understood to have based their new demands on the increased outputs obtained by the industries during the past year, the high level of profits, and the rise in the cost of living. Mr. Jack Tanner, the President of the Amalgamated Engineering Union, who headed the Confederation's officials, is believed to have put forward an analysis of overtime work in the industries, with the object of showing that a large proportion of the workpeople obtain little or no addition to their earnings from that source. In spite of there having been a rise of only three points in the index of retail prices since November last year, when all engineering operatives received an advance of 7*s.* 4*d.* a week, it is also a part of the Confederation's case, apparently, that wages have not kept pace with prices since June, 1947, when the index was commenced. The Federation's representatives agreed to investigate the demands and to arrange for a further joint meeting in due course. This will probably take place in September, after the Federation has consulted its affiliated organisations.

Suggestions that engineering employers would be pleased to see their workpeople earning higher wages were put forward by Mr. H. A. Smith, President of the Engineering and Allied Employers' South Wales Association, at a Press conference at Cardiff on Monday. He issued a warning, however, that the employers would be hard to convince that an increase was justified, unless it was strictly related to higher productivity. As the majority of operatives in the engineering industry were employed on piecework, or under the terms of bonus schemes, which were directly related to production, an increase in productivity, and consequently in wages, could be obtained without detriment to selling prospects in the export market. An increase of only 5 per cent. in productivity would solve all the nation's balance-of-trade problems. This small increase would be hard to obtain owing to restrictive practices, particularly with regard to piecework.

Piecework earnings, Mr. Smith continued, were too often regulated by the speed of the slowest employee in the shop, in an endeavour to maintain existing rates. An agreement by the workpeople to produce the maximum output for each individual would immediately bring about an increase in real wages to all but the slowest employees. Wage rates quoted by the unions in negotiations were minimum time rates and excluded piecework earnings, bonuses, and overtime. It was apparent that the unions clearly understood that the only hope of obtaining an increase lay in quoting wage rates applicable to only a small proportion of the industry's employees.

A corresponding claim for a 15 per cent. increase in wages, on behalf of adult men employed in the shipbuilding and ship-repairing industries, was presented by the Confederation to the Shipbuilding Employers' Federation last Friday. Mr. E. J. Hill, the general secretary of the United Society of Boilermakers, Shipbuilders and Structural Engineers, who led the Confederation's deputation, is understood to have put forward similar arguments to those introduced by Mr. Tanner on behalf of engineering workpeople. The Federation's representatives agreed to consider to the claims and to meet the unions' representatives again.

The difficult question of official recognition for small craft organisations, especially those connected with the Civil Service, is likely to come to the fore during the next few days. It was announced last Saturday that Sir Robert Grimston, a former Assistant Postmaster-General, Mr. Anthony Marlowe, and some 22 other Members of Parliament, had tabled a motion stating "That this House re-affirms its adherence to the principle of free association and considers that the time has now come for H.M. Postmaster-General to accord recognition to the Engineering Officers (Telecommunications) Association." This body was formed some time ago among employees in the telecommunications branch of the Post Office and it has since been struggling to obtain official recognition as a trade union. The supporters of the motion maintain that, when the Conservatives were in opposition they advocated acceptance of the Association's claims.

Demands that careers in the professional grades of the Civil Service should offer the same advantages as those in the administrative grades were put forward by the Institution of Professional Civil Servants some time ago. It was announced last Saturday that these demands had been met, in part, by an award of the Civil Service Arbitration Tribunal, under the terms of which some increases in salary would be granted, but without the parity of treatment the Institution had requested. The award will provide a salary of 400*l.* a year, with an increase to 525*l.* on confirmation of appointment, and rising to 750*l.* a year, for scientific officers. Salaries of senior scientific officers will range from 850*l.* to 1,000*l.* a year, and those of principal scientific officers from 1,000*l.* to 1,375*l.* a year. The award will take effect from August 1.

Some 2,000 dockers at the King George Dock, Hull, went on strike last Saturday morning on the ground that demands for extra pay, put forward by gangs employed in discharging maize under trying conditions, had been refused. The men complained that maize in the s.s. Argodon, a British ship, was being discharged in a temperature of 115 deg. F., and that the equipment provided for the purpose was out of date. In such circumstances, a ship is usually discharged by mechanical means. Difficulties had been apparent for some days and negotiations on the pay aspect commenced early last week. These failed to produce a satisfactory offer and a call to take strike action resulted.

Men employed at the adjoining Alexandra Dock, and at other docks in the port, ceased work in sympathy, and it was estimated at the end of the day that some 4,000 men, engaged on more than 30 ships, were idle. Officials of the Transport and General Workers' Union, to which the men belong, made immediate efforts to have the dispute dealt with by the port's conciliation machinery. At a mass meeting last Saturday, the men accepted the advice of their leaders and decided that they would return to work on Monday, in order that negotiations on the original difficulty might proceed. The stoppage occurred at a time when the docks at Hull were being worked almost to capacity.

General agreement on the function and powers of pit efficiency committees in the Yorkshire coalfield was reached at a conference between senior officials of the North-Eastern Divisional Coal Board and representatives of the Yorkshire area of the National Union of Mineworkers, at Doncaster, on July 21. Although the National Coal Board has given these committees authority to deal with questions of efficiency, they have opposed the delegation of power to deal with wages and prices. In return for the acceptance of this principle, the union has been allowed to have a third representative on all pit efficiency committees.

VIBRATING-WIRE STRAIN GAUGE.

Fig. 1. B.R.S. VIBRATING-WIRE STRAIN GAUGE.

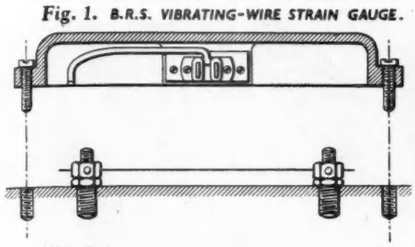
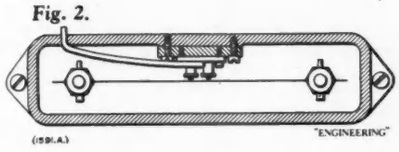


Fig. 2.



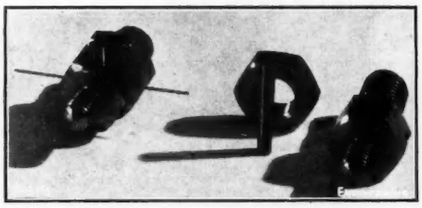


FIG. 3. GAUGE POSTS OF B.R.S. STRAIN GAUGE.

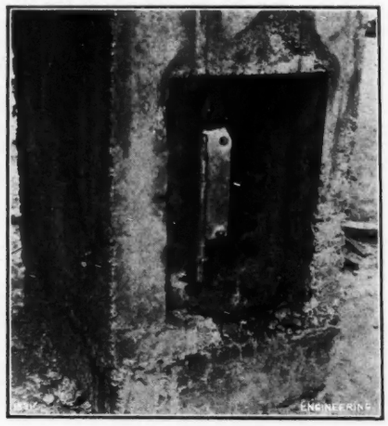


FIG. 4. TENSIONING DEVICE FOR STRAINING THE GAUGE WIRE.

FIG. 5. PORTABLE PICK-UP FOR READING GAUGES.

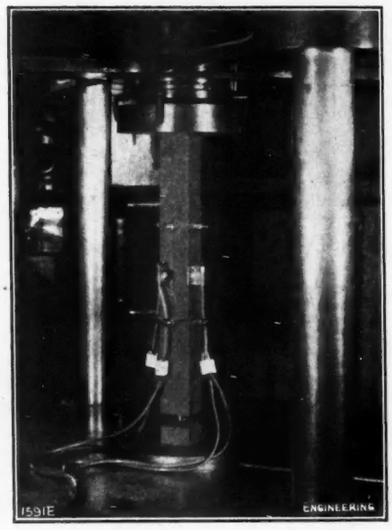


FIG. 6. CALIBRATION COLUMN WITH FOUR VIBRATING-WIRE GAUGES.

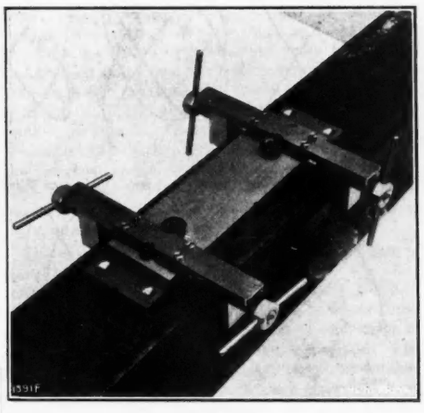


FIG. 7. DRILLING JIG FOR GAUGE-POST HOLES.

VIBRATING-WIRE STRAIN GAUGE FOR USE IN LONG-TERM TESTS ON STRUCTURES.*

By R. J. MAINSTONE, M.ENG.

THE Building Research Station has recently commenced a number of long-term field observations of stresses in structures, both during erection and afterwards. The stress histories obtained are providing a valuable guide in planning future laboratory work and a check on the applicability of that work to full-scale structures. The first studies undertaken were of the stresses induced in the steel frame of a large office building by differential settlement of the foundations, and of the relief of stress in the steel beams of the same building due to the stiffening effects of concrete casing, floors and walls. This article describes the strain gauge developed for this work and the experience obtained in its use. The same gauge, with slight modification in one case, has since been used for similar tests in a prestressed concrete building, on a steel-and-concrete highway bridge, and in a tunnel driven through London clay and lined with cast-iron segments.

The essential requirements were for a gauge which would give consistent readings over a period of several years, and could, when necessary, be buried in concrete and read at a distance. It was also necessary for the gauge to be fitted to steelwork before erection without risk of damage later by shock or vibration. The electric resistance gauge, though it can be read at a distance, is liable to give readings which drift with time due to instability of the cement when the temperature and humidity vary, and no wholly successful application of it, or of any other purely electrical strain gauge, in a long-term test was known. Only the vibrating-wire gauge, as it had been used by André Coyne to measure strains in concrete dams,[1] and, in the laboratory, by the Institut Technique du Bâtiment et des Travaux Publics for tests on the shrinkage and creep of concrete,[2] was known to have proved satisfactory for such work. Some of these French tests extended over a period of several years, with apparently little trouble from the gauges. So, on the basis of such experience, the vibrating-wire gauge was selected.

In principle the gauge consists of a stretched steel wire held at its two ends to the member under test and made to vibrate at its natural frequency which is characteristic of the strain to which it is subjected. If the member suffers a change in strain, the wire undergoes a proportionate change and a measure of it is given by the change in frequency. The law connecting frequency and strain is of the form $n^2 = \text{constant} \times \frac{e}{l^2}$, where n is the frequency, e the strain and l the free length of the wire; but, by tuning the measuring wire against a reference wire the strain of which can be varied by a calibrated control and the frequency of which is governed by a similar law, changes in strain are given directly by differences in a scale reading. Tuning of the wires may be aural, by listening to their notes in headphones or a loudspeaker and reducing the beat frequency to zero, or visual, by using oscillating electric-potentials generated by the two wires to deflect the electron ray of a cathode-ray tube in two directions at right-angles and then obtaining a stationary elliptical Lissajous figure on the screen.

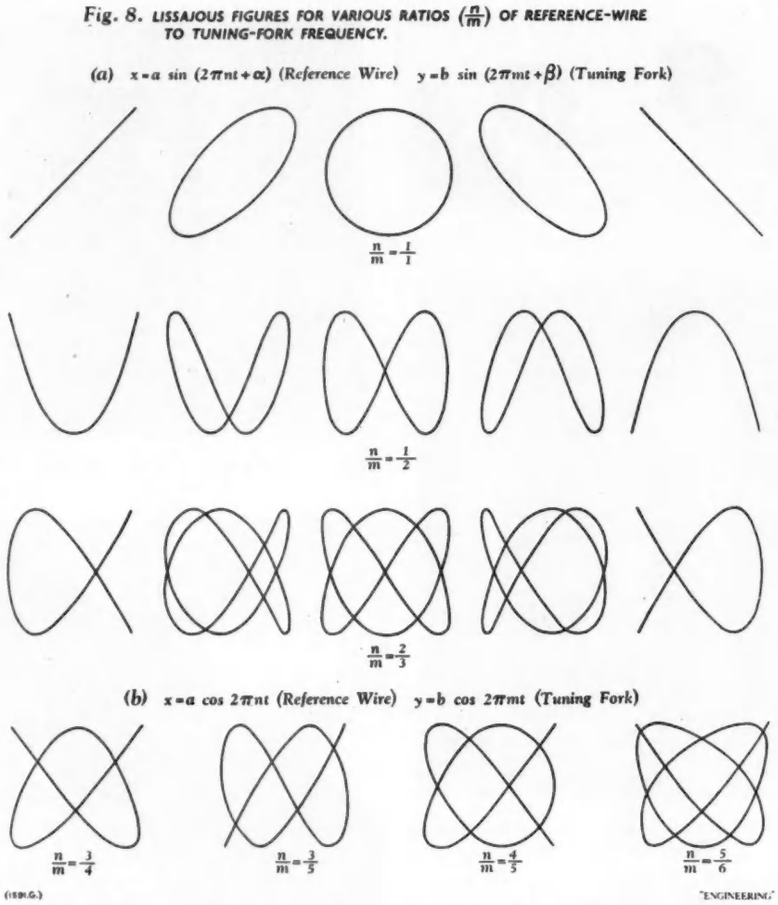
Different forms of the measuring gauge differ essentially in the means whereby the wire is held to the member under test. So that the wire strain, e, shall be proportional to the strain of the member, the total relative movement over a closely defined gauge length of the member must be applied to an equally closely defined length of wire. The strained length of wire, however, need not necessarily be the same as the gauge length, provided that the first remains a constant proportion of the second for gauges that are required to have the same calibration. Neither need it be the same as the length of wire, l, the free vibrations of which give an indication of the strain. This length, l, can be, and sometimes is, limited to some shorter length between two bridges, as in many musical instruments. In the two forms of the gauge hitherto extensively used in this country, the Maihak gauge used by the Steel Structures Research Committee[3] and the B.R.S. gauge used mostly in loading tests on bridges,[4] the gauge length is ideally defined by two knife edges, one on each of the blocks carrying the ends of the wire, though the strained length of wire is perhaps a little less well defined. Both these gauges are self-contained so that they can easily be clamped to any member under test, and are so designed that the knife edges are always initially the same distance apart. They are accurate and sensitive and eminently suitable for short-term work. But, being designed for easy fixing and easy removal for re-use elsewhere, they lack the permanent and robust means of anchorage essential for long-term field work, and are rather costly for use in positions from which they cannot be retrieved. For the present tests, a simpler, more robust and cheaper expendable gauge was therefore designed.

In this new measuring gauge a small sacrifice of definition of the gauge length was deliberately accepted in order to eliminate the risk, inherent in the clamped knife-edge mounting when subject to shocks or heavy vibration, of slight slipping of the blocks carrying the wire. The same choice appears to have been made by the French investigators referred to but, whereas they used posts welded to

* Communication from the Building Research Station of the Department of Scientific and Industrial Research, Garston, Watford. For References, see page 156.

VIBRATING-WIRE STRAIN GAUGE.

Fig. 8. LISSAJOUS FIGURES FOR VARIOUS RATIOS ($\frac{n}{m}$) OF REFERENCE-WIRE TO TUNING-FORK FREQUENCY.


(a) x = a sin (2πnt + α) (Reference Wire) y = b sin (2πmt + β) (Tuning Fork)
n/m = 1/1
n/m = 1/2
n/m = 2/3
(b) x = a cos 2πnt (Reference Wire) y = b cos 2πmt (Tuning Fork)
n/m = 3/4
n/m = 3/5
n/m = 4/5
n/m = 5/6
(ISOLG.)
"ENGINEERING"

a steel member to carry the wire, it was considered preferable in the present work to use posts screwed into prepared holes in the steel. The loss in definition of the gauge length then results from the local modification in the conditions of strain in the member under test around each hole, due to which the total movement between the centres of the posts is not quite the same as it would have been if the posts had not been carried into the member. A theoretical study at the Building Research Station,[5] however, has shown that with the post diameter that has been adopted, of about $\frac{1}{4}$th of the gauge length, this effect is very small. Moreover, the effect varies little between different gauges since, by using lock-nuts to prestress the threads, the posts are made, in effect, integral with the member under test, and this similarity of behaviour of different gauges, which has been confirmed in the standard calibration test described later (in which four typical gauges are calibrated simultaneously), makes it unnecessary to calibrate each gauge independently. Also, since the experimental calibration automatically allows for the modification of the strain in the member caused by the insertion of the posts, the small loss in definition of the gauge length becomes of negligible importance.

The gauge is illustrated diagrammatically in Figs. 1 and 2, on page 153. A 6-in. gauge length has been adopted as standard. Two posts, shown in more detail in Fig. 3, are screwed into $\frac{3}{8}$-in. B.S.F. holes in the member, 6 in. apart, and are held rigidly there by lock-nuts which also prevent them from turning out of alignment. The 0·018-in. diameter wire passes through each post in a hole allowing a very slight clearance in the centre but counterbored at each end. A second tapered hole runs through each post at right-angles to, and slightly higher than, that for the wire. It is so aligned with respect to the latter that a tapered pin driven through it squeezes the wire from above by about one-third of its diameter and grips it against the bottom of its hole. To complete the assembly, the wire is threaded through both posts and gripped in one, while a tension, sufficient to give a conveniently measurable frequency throughout its working range, is applied by a calibrated spring in a tensioning device which fits over the upper threads on both posts, as shown in Fig. 4, page 153. This illustration shows a gauge being fitted to a building in course of erection. The pin is then driven home to grip it in the second post and the tensioning device is removed. With this method of gripping the wire, the strained length of wire is closely defined by the pins and is almost equal to the effective gauge length. The free vibrating length of wire, l, is assumed to be the slightly shorter length defined by the ends of the counterbores. This is measured accurately for each gauge.

As indications of stresses were required for several years, sometimes from gauges exposed to damp, all these components, including the wire, were made of stainless steel for the first tests. On the suggestion of Mr. C. C. Hall, of the Brown-Firth Research Laboratory, the wire, which must be magnetic and of sufficient tensile strength not to creep in use, was specially drawn from Firth-Vickers F.I. 20 steel (0·06 C, 0·31 Si, 0·70 Mn, 21·0 Cr). It has a breaking load of 48 lb., and to reduce the risk of creep it was so fitted in the gauges on the steel-framed building that its working tension has not subsequently exceeded 12 lb. (corresponding to a frequency of about 700 cycles per second). For the prestressed concrete building, however, a higher working tension was adopted and a silver-plated piano wire was used.

To make the measuring wire vibrate in order to take a reading, it is plucked electromagnetically by discharging a condenser through a small electromagnet held close to it. The same electromagnet —a standard telephone insert—picks up the subsequent vibration as that oscillating electric potential which, after amplification, is fed to the earphones or cathode-ray tube. For gauges that have been left accessible and protected only by light movable covers, a portable "pick-up," incorporating the electromagnet and screwed down over the upper threads on the posts, is used. This can be seen in Fig. 5, where it is in use for reading the gauge shown in Fig. 4 after the building was completed. Other gauges, which had to be buried in concrete or were otherwise not easily accessible, had permanent covers fitted over them. Figs. 1 and 2 show the cover which was fitted to the beams of the steel-framed building, to the cast-iron segments of the tunnel lining, and in other cases where protection was required against accidental blows during the erection of the structure. It is made of heavy section cast iron and carries the electromagnet mounted on one side. Where less protection is needed, a lighter sheet-brass cover is used. With both forms of permanent cover, the electromagnet is waxed over after assembly, and the cover is made watertight by sealing the base with "Rito" bituminous compound when it is fitted; this always remains slightly plastic, so that there is no risk of cracks forming in it and breaking the seal.

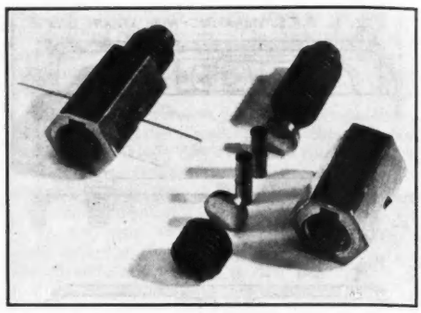


FIG. 9. REDESIGNED GAUGE POSTS.

Two standard types of reference gauge have been used. Both have been described before. In each the reference wire is maintained continuously vibrating at its natural frequency and its vibrations are continuously fed to the earphones or cathode-ray tube, but the two types differ in the means adopted to vary the wire tension. In the Maihak gauge[6] the wire is strained by means of a micrometer screw acting directly through a cranked lever, whereas in the B.R.S. gauge,[7] and in the Muirhead gauge based on it, the wire is strained by a micrometer screw acting through a helical spring. A scale attached to the micrometer screw gives a reading proportional to the wire strain or tension.

The amplifying circuits for both acoustic and visual balancing have also been described before[8] and will not be described here. Both methods of balancing have been used. Many of the readings in the early stages of the tests had to be taken amid the noise of drills, riveters and other contractors' equipment on the site, and it was found that under these conditions acoustic balancing took much longer than visual balancing and was much more fatiguing. As far as possible, therefore, visual receiving sets are now used, and it is one of these, incorporating a Maihak reference gauge, which is shown in use in Fig. 5. Comparative tests have shown that visual balancing is also usually more sensitive and accurate, though this depends to some extent on the operator.

Since measurements are made solely by the matching of frequencies, no special precautions are needed in making the connections between the gauges and the receiving instrument, and, even if a large number of gauges is used, the switchgear can be very simple. Herein lies another advantage of the vibrating-wire gauge compared with electric-resistance and similar gauges.

A less obvious feature of the vibrating-wire technique of strain measurement is that, though measurements are made by comparing the frequency of a measuring wire with that of a reference wire

VIBRATING-WIRE STRAIN GAUGE.

FIG. 10. GAUGES FITTED ON FLANGES OF STEEL BEAMS.

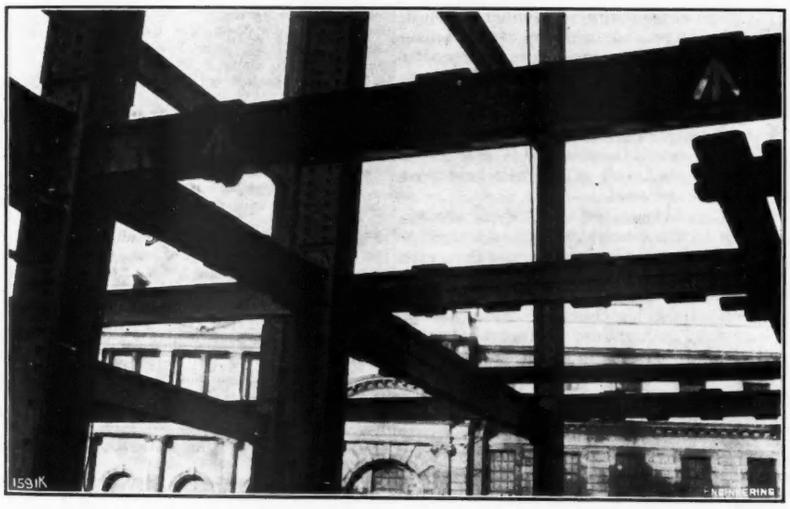


FIG. 11. BEAMS AFTER ERECTION, WITH GAUGES FITTED.

of which the strain can be varied at will, the reference and measuring wires need not be of the same form. In fact, in none of the standard models of reference gauge used in the present tests is the wire of the same length or diameter as in the specially-designed measuring gauge. It is sufficient that the frequencies of the reference and measuring wires should obey similar laws and should cover the same working range. Also, in taking a reading, neither the strain nor the frequency of the reference wire need be known; nor even the exact relationship between them. These features arise from the fact that each strain measurement is best made, in effect, by a double comparison. In this, the reference wire plays only the intermediate role. It is balanced, in turn, against the measuring wire which indicates the unknown strain and against a second similar measuring wire fitted to a calibration member subject to a known strain; thereby the unknown strain is compared with the known. The second balancing is, in practice, one of a series that constitutes the initial calibration of the reference gauge, and covers the whole range of strain.

The reference gauges used were therefore calibrated, not primarily against frequency standards, but against typical measuring gauges mounted, usually, on a calibration column. This is a 2-in. square-section steel column which carries one gauge on each face, and is seen mounted in a testing machine in Fig. 6, page 153. A calibration curve of column load against reference-gauge scale reading is plotted and should be sensibly a straight line. A similar calibration in which the vibrating gauges are replaced by roller-mirror gauges gives the modulus of elasticity of the column and enables a calibration constant of the form "indicated strain per reference-gauge scale division" to be calculated. This is the constant for the reference gauge tested when used with measuring gauges identical with those on the column. The only significant variation liable to occur between different measuring gauges of the present type is in the spacing of the posts and, consequently, in the free vibrating length l of wire. It follows from the relationship between wire strain and frequency that, if the experimentally determined calibration constant is for a free vibrating length of wire l, the constant for another measuring gauge with a free vibrating length of wire λ, when used with the same reference gauge, will be given by multiplying the first one by $\frac{\lambda^2}{l^2}$.

In practice, it has usually been possible to use some form of jig, such as that shown in Fig. 7, page 153, to ensure that the holes for the posts are drilled parallel to one another and normal to the surface, and to maintain the spacing within close limits, and this correction has then been small enough to be ignored.

Sometimes it has been useful to perform an additional calibration using a full-size member from the structure under test, such as a beam from the building frame or a segment from the tunnel lining, instead of the calibration column. In this case measuring gauges are fitted to the beam or segment as in the actual structure, and loads are applied similar to those which arise in practice. A relationship is then established directly between the reference-gauge scale divisions and the applied load, or measured deflection, or any other desired quantity. In some such calibrations, however, the relationship is not necessarily linear.

FIG. 12. GAUGES FITTED TO CAST-IRON SEGMENT OF TUNNEL LINING.

The calibration constants of the reference gauges have been of the order of from 1 to 4×10^{-6} strain per division, and, since it is usually possible, with a cathode-ray tube, to balance to within half a division, the reading accuracy is of the order of from $\pm 0{\cdot}5$ to $\pm 2 \times 10^{-6}$ strain per division. The true accuracy of a reading may, however, be less than this. The factors which may reduce it may conveniently be grouped under three headings: (1) any form of instability in the reference gauge and the electronic circuit used for balancing; (2) any variation of the measuring-gauge frequency independent of strain, due, for instance, to dirt on the wire, variable excitation or damping of the wire, or thermal expansion of the wire relative to the member in which the strain is being indicated; (3) any creep, slip or frequency instability of the measuring-gauge wire. It should be stressed that the first group of possible disturbing influences is entirely independent of the special design of measuring gauge which forms the main subject of this article, while the second group is characteristic of all vibrating-wire measuring gauges of whatever form. Only the third group is dependent on the method of mounting the measuring wire, and it was to minimise this group of disturbances in long-term field tests that the present gauge was designed.

Effect of Reference Gauge on Accuracy.—Throughout the tests it has been the practice to check the stability of the reference gauges by balancing each against a standard tuning fork from time to time. Usually this has been done only at the tuning-fork frequency, but sometimes also at convenient multiples of this covering the whole frequency range of the gauge. The latter is possible only with visual balancing, since the technique used depends on recognising characteristic Lissajous figures on the screen of the cathode-ray tube.[6] The top row of Fig. 8 (*a*), opposite, shows the Lissajous figures for two matched vibrations of equal frequency but with different phase differences. These are the traces seen on the screen in the simple check of the reference gauge against the tuning fork at its own frequency, that is, $\frac{n}{m} = 1$, and when taking any normal reading by balancing the reference gauge against a measuring gauge. The two lower lines in Fig. 8 (*a*) show the corresponding figures

seen when balancing simple multiples, $\frac{n}{m} = \frac{1}{2}$ and $\frac{2}{3}$ of reference-gauge frequency against other simple multiples of the tuning-fork frequency in the more complete check. Fig. 8 (*b*) shows figures for larger multiples of reference-gauge and tuning-fork frequency, but here only in their simplest form, in which the two vibrations are periodically in phase at full amplitude. By concentrating on these simplest forms it has been found possible to recognise multiples of up to 16 times either frequency.[10] The complete check by this technique therefore covers the whole range of the reference gauge almost as thoroughly as a check against a decade oscillator, though a little less evenly, while it has the great advantage that it uses only a single and easily portable standard—the small tuning fork.

The checks have disclosed small random variations in the zero readings of the reference gauges (i.e. the readings at the tuning-fork frequencies) from day to day, week to week, and month to month within limits of up to ± 5 divisions. The variations appear to occur sometimes even when the gauge is undisturbed, but fortunately they are very slow compared with the rate of taking readings and are usually insignificant, over the period of a few hours necessary to complete a series of readings. Also, the checks over the whole frequency range have shown that the displacement of the reading is very nearly uniform throughout the range, so that a correction for it is very easily made. Instability of the reference-gauge vibrations over a shorter period, which can arise if the wire is driven by the exciting circuit instead of vibrating freely or if its temperature changes in relation to that of its mounting has been largely eliminated by suitable design of the circuits and layout of the receiving instruments.

Effect on Accuracy of Features Common to All Measuring Gauges.—Dirt on the measuring wire can, by increasing the vibrating mass, reduce the frequency and hence the indicated strain. Excessive excitation and damping of the wire, which occur only when the pole-pieces of the exciting electromagnet are moved very close to it, can also have a marked effect on the reading. The remedy in both cases is simple and obvious, and it is worth noting that, given due care in the initial assembly, no trouble can arise from either of these causes in the permanently-enclosed type of gauge fitted in most of the present tests. Variable excitation of the wire, sufficient to disturb the reading, has been noticed, however, in a very few of these gauges when the direction of the circuit through the electromagnet was reversed. This appears to be due to a fault in the winding of the magnets concerned. Whatever the cause, no error is introduced if each gauge is always connected to the exciting circuit in the same way.

As in many other types of gauge, thermal expansion of the measuring wire and the member the strain of which it is indicating can also sometimes give rise to spurious strain indications. These may be due solely to differential heating of the wire and the member, or they may arise from a difference in coefficients of expansion. It has been found, though, that the permanently-enclosed gauges are adequately protected against such differential heating, and that when they are used on steel the effect of different coefficients of expansion is negligible. When they are used on concrete and other materials, corrections can be made by the usual techniques.

Effect of the Method of Mounting the Measuring Wire on Accuracy.—The behaviour of the measuring wire as mounted in the new posts has been carefully investigated to see whether there is any creep or slip of the wire or any other slow change in it with a similar harmful effect, and to find what is its general frequency stability. As the principal check, four typical gauges with permanent covers and exciting electromagnets were fitted, one on each face, to a 3-in. square-section steel column. This was mounted in a closed box in the laboratory in such a way that it could suffer no external strain and has since been kept at constant temperature. All the gauges were fitted with the usual stainless-steel wire with a breaking load of 48 lb. In two of them the wire tension is about 8 lb., and in the other two about 12 lb. Readings were taken at weekly intervals over a period of more than a year after assembly and showed no systematic variation and therefore no noticeable creep or slip or other similar change in characteristic of the wire. The only variation in the indicated strain was a slightly erratic one between the limits of $\pm 2 \times 10^{-6}$. This includes any reading errors and any other uncorrected variation introduced by the reference gauge, but, even if it is all attributed to the measuring wire, the frequency stability of this wire under laboratory conditions is seen to be of a very high order.

In the field tests, after completion of the parts of the structures on which the gauges were mounted, conditions have been similar to those of the laboratory, and a similar frequency stability and freedom from creep or slip of the wire can then reasonably be claimed. Prior to this, however, the gauges, in many cases, have been disturbed frequently and rudely. The members on which they were mounted have been roughly handled during erection or they have been badly shaken by the use of pneumatic riveters or drills a few inches away from them. Each disturbance might have produced a sudden slip of the wire of a type which the laboratory test was not designed to disclose, and with an effect on the reading like that of the slipping of the knife edges, under similar conditions, in a clamped knife-edge mounted gauge. To find whether there was any such slip of the wire, the readings taken in the early stages of the tests were carefully examined. A marked drop in reading, indicative of a slackening of the wire, did occur in one or two gauges after the first rough treatment. On dismantling them, however, the wire was found to have been excessively squeezed by the taper pin on assembly, due to faulty alignment of the holes in the post. Subsequently, sudden unaccountable changes in reading due to slackening of the wire have been remarkably few and small.

In the tests commenced first—those on the steel-framed building, to which the largest number of gauges was fitted—it may be claimed that, with the simple procedure to minimise errors referred to above, the overall accuracy of the "long-term" readings of strain has been of the order of $\pm 10 \times 10^{-6}$. In short-term loading tests, conducted from time to time in conditions more like those of the laboratory, the accuracy has, of course, been much higher. Only in one respect have some of the gauges fitted in the first tests given trouble: the connections to the exciting electromagnets inside the permanent covers have failed after a year or two, thus permanently isolating these gauges. This is a fault which arose largely because of the speed with which the gauges had to be installed; it can be avoided by taking sufficient care in assembly.

The posts shown in Fig. 3, however, have been a little difficult to manufacture, since it is not easy to align the holes for the wire and the taper pins within the very close tolerance that must be imposed. To overcome this defect the post shown in Fig. 9, page 154, has been designed. While not departing in any essential principle from the earlier design, the components are all either standard parts or ones which can easily be made to the required tolerance. The main bolt is screwed down hard to the bottom of the hole prepared for it, giving the required pre-stress to the threads without any lock-nut, no special alignment being necessary. The large annular nut is then screwed over it and correctly aligned, and the remaining parts are assembled within it in the order shown in the "exploded" view, the short top screw being finally locked against the main bolt to make the whole assembly rigid. The wire is gripped between the two small pins, which define both its strained length and its free vibrating length, both of these being equal to the distance between the centres of the posts. The design is still in the experimental stage and it is hoped that further simplification may be possible.

Figs. 10 to 12, page 155, show the gauges in use in the field. In Fig. 10 several gauges have been fitted along the flanges of steel beams before the latter were erected in a building. The beams are shown erected in Fig. 11; later, the gauges were buried in the concrete casing. Fig. 12 shows three gauges fitted to the cast-iron segment of a tunnel lining.

REFERENCES.

[1] "Quelques resultats d'Auscultation Sonore sur les Ouvrages en béton, béton armé ou métal," by André Coyne, *Annales de l'Institut Technique du Bâtiment et des Travaux Publics*, 3e année No. 4 (Juillet-Aout, 1938), pages 33-56. The same paper is summarised in *Le Génie Civil*, vol. 113, pages 286-288 (1938).

[2] Referred to in many publications of the Laboratoires du Bâtiment et des Travaux Publics. See especially "Le Mesure de la Déformation des Solides," by J. Barrée, *Compte Rendu des Recherches effectuées en* 1944-45, pages 11-13; and "Recherches Expérimentales sur la déformation du Béton et du Béton Armé," by B. Le Camus, *Ibid.*, 1945-46, pages 170-176.

[3] "Messaite für einen akustischen Dehnungsmesser," by H. Maihak A.G., *Reichs patentschrift*, No. 550,721 (1932); "Le télé-extensométre acoustique du Dr. Schaefer," by F. Campus and R. Dantinne, *Cours de Constructions du Génie Civil*, University of Liege, No. 11 (1932); and reports of the Steel Structures Research Committee, especially "An Investigation of the Stress Distribution in a Number of three-storey Building Frames," by J. F. Baker, 2nd Report. H.M. Stationery Office (1934), pages 242-243; and "An Investigation of the Stress Distribution in the Steel Framework of a Modern Hotel Building," by J. F. Baker and P. D. Holder, Final Report. H.M. Stationery Office (1936), pages 12-17 and *passim*.

[4] "Improvements in Extensometers and Strain Gauges," by Norman Davey, British Patent Specification No. 434,509 (1935); and "Measuring the Existing Stresses in Masonry Structures," *The Engineer*, vol. 159, pages 442-443 (1935); "The Strength of Cast-Iron Bridges," by C. S. Chettoe, N. Davey and G. R. Mitchell, *Jl. I.C.E.*, vol. 22, pages 255-257 (1944); and "The Acoustic Strain Gauge," by R. S. Jerrett, *Journal of Scientific Instruments*, vol. 22, pages 29-34 (1945).

[5] By Dr. R. H. Wood; not yet published.

[6] "Report on Visit to H. Maihak A.G., Hamburg," British Intelligence Objectives Sub-Committee, Final Report No. 149, Item No. 9, 31, H.M. Stationery Office (1945).

[7] Norman Davey and R. S. Jerrett, *op. cit.*, describe the B.R.S. reference gauge. The gauge manufactured by Messrs. Muirhead differs in detail from this in the form of the connection between the wire and the helical spring, the small leaf spring of the original B.R.S. gauge being replaced by a rocking arm.

[8] R. S. Jerrett, *op. cit.*, and H. Maihak A.G., "Improvements in Tensometer Apparatus," British Patent Specification No. 519,172 (1940).

[9] The technique developed at the Building Research Station is similar to that described in text-books on frequency measurement and the cathode-ray tube, such as "The Cathode-Ray Tube and its Applications," by G. Parr (London, 1942), and "Cathode-Ray Tube Traces," by Hilary Moss (London, 1949). The latter was previously published in *Electronic Engineering*, vol. 17, page 21 (1944).

[10] It has been found helpful in interpreting or drawing the more complex figures to visualise them as projections on to the plane of the screen of sine waves traced round a transparent cylinder with its axis lying vertically or horizontally in that plane. If, for instance, m times the reference8wire frequency (x shift) is balanced by n times the tuning-fork frequency (y shift), the numbers m and n being integral, a closed figure is obtained which resembles m complete sine waves circling a vertical cylinder n times. A change in phase of the two vibrations is represented by a rotation of the cylinder.

INSTITUTION OF ELECTRICAL ENGINEERS.—The annual summer meeting of the Supply Section of the Institution of Electrical Engineers will be held at Porthcawl, South Wales, from Thursday, September 24, to Sunday, September 27, 1953. Visits will be paid to the Llandarcy oil refinery, the Abbey Steel Works at Margam, the works of the Metal Box Co., Ltd., at Neath, a colliery, and a woollen mill. Further particulars may be obtained from the secretary of the Institution, Savoy-place, London, W.C.2.

SUMMER SCHOOL FOR FOREMEN.—The Institute of Industrial Supervisors, 47, Temple-row, Birmingham, 2, is organising a summer school for foremen to be held at Dillington House, near Taunton, from Thursday, September 3, to Thursday, September 10. The school will include three of the Institute's short residential courses and the programme is designed so that each of these can be taken separately. Each course is planned so as to be of direct and practical help to foremen and there will be ample opportunities for the exchange of ideas and experience. The subjects of the three courses are: "The Practice of Supervising Management"; "Industrial Relations and Industrial Law—What the Foreman should Know"; and "Work Study for Supervising Management."

INDUSTRIAL APPLICATIONS OF RADIOACTIVE MATERIALS.*

By SIR JOHN COCKCROFT, K.C.B., F.R.S.

RADIOACTIVE elements have two distinguishing characters. First, the average time they exist before changing their nucleus varies greatly—we specify this by a so-called "half life"—the time during which half the nuclei will change over; second, by the characteristics of the radiations they emit in the process. The half lives of radioactive elements range from micro seconds to millions of years. The radiations, whether of electron or gamma rays, are specified by giving their energy in electron volts. Thus, radio cobalt, which is much used in radiography, has a half life of about five years and gives out gamma rays of a little over one million electron volts energy. The energy of the radiation determines its penetrating power and the cobalt radiation will penetrate in a useful way 2 in. to 6 in. of steel.

Radioactive elements were created in a wide variety in the initial creation process of our Universe about three billion years ago. Since that time most of the short-lived elements have returned to stability, leaving, however, a few important radioactive elements, particularly among the heavy elements. The best known are uranium and radium, but there remain altogether 16 of the radio elements created by nature. Radium has a half life of 1,600 years and gives rise to a chain of unstable daughter products, some of which—such as radon—are useful to industry. The first application of radioactive elements to industry came, therefore, from the use of radium and its decay products.

Most of the radio elements available to industry are now made in an atomic pile, which, in the case of the Harwell pile, now a principal source of creation of these elements, consists of a pile of very pure graphite blocks between which are spaced 20,000 bars of uranium metal clad in aluminium. The uranium nuclei split up at a controlled rate and throw out neutrons which split up more uranium nuclei in a so-called chain reaction. Heat equivalent to about 6,000 kW is developed in the uranium metal bars; powerful gamma rays are emitted and neutrons fly about in all directions at high speeds. The uranium nuclei split up into two fragments which are usually radioactive. So, among the fission products we have at least 30 kinds of radioactive elements.

RADIOGRAPHY.

The industrial applications of radioactive elements are now in an interesting growing stage. The oldest application is to radiography, since radon, the gaseous daughter of radium, has long been and is still used for this purpose. The radioactive elements provide a wide range of radiations, which can be chosen to suit the job. At one end of the energy scale the radiations from thulium 170, which have the modest energy of 85 kV, are very suitable for radiography of light alloys, since great penetration is not required and good contrast is obtained. Radio iridium (192) emits gamma rays of 600 kV maximum energy and is useful for thicknesses of steel between ½ in. and 2 in. It can be obtained in very strong sources and is used widely for testing welded boiler plates and steam pipes. A typical technique is to insert the small source on the axis of a pipe and to wrap a flexible cassette of film round a peripheral weld. A 15-minute exposure will then reveal the whole weld in a picture that can be shown to the welder. In New Zealand, I visited a new hydro-electric station and was interested to find that faulty welds in some of the penstocks were being radiographed on the site by the use of radio iridium sources flown out in seven days from Harwell.

The radio iridium has the advantage of high intensity for a given price, but loses half its activity in 70 days and has to be returned to the pile to be reactivated. Radio cobalt has a longer half life of 5·3 years and emits gamma rays of 1,200 kV energy. It is therefore useful for steel thicknesses of up to 6 in.

Radioactive elements can also be used to show up fine surface cracks in metals. An experiment was carried out for the de Havilland Aircraft Company, who wished to search for fine cracks in propeller metal. A solution of radio phosphorus—which emits electrons—was made in a detergent in order to reduce the surface tension. The solution thus spread uniformly over the surface. After removing the surplus, a photographic film was put in contact with the metal surface. Since the radio phosphorus solution had penetrated the cracks the film was blackened in the position of the cracks. This is the method of radio autography.

USE OF RADIATION TO DETERMINE STRIP THICKNESSES.

The number of electrons transmitted by materials depends on the thickness of the material, its density and the energy of the electron. We can therefore measure continuously the thickness of strip as it comes from the rolling mill, by placing a radioactive source emitting electrons on one side of the strip and a meter to measure the electron intensity on the other. Gauges of this kind are in use commercially for the measurement and continuous thickness-control of steel, brass, copper, cardboard, plastic film, paper. Thallium 204 is used for materials having weight up to about 120 milligrams per square centimetre. Strontium 90 emits more penetrating electrons and is used up to four times greater density of material—up to ¼ in. aluminium for example. For still heavier materials, gamma rays from iridium can be used. This same property of radiation can be used to act as a control on package filling. Thus it is possible to detect that a single tablet is missing in a packet of aspirin.

Radioactive gauges can also be built to measure the thickness of plating, such as tin plating. The electrons from a radioactive source are scattered backwards into a counter, mainly by the tin layer, which is heavier than the substrate. By such a device the thickness of the tin plate can be measured with an accuracy of 0·00001 in. This same method of back scattering can be applied to measure the wall thickness of steel tubes having diameters of 2 in. upwards and a wall thickness of 0·1 in. to 1 in. Quite small sources can be used and measurements of wall thicknesses can be made with an accuracy of 3 to 4 per cent. This enables the corrosion of tubes to be followed. There is a possibility that coal can be separated from shale by taking advantage of the different scattering of gamma rays. Thus, in a preliminary test, it was found that the radiation from thulium was back-scattered about 25 per cent. more from coal than from shale. A belt conveyor would carry the coal plus shale, and an ejector would get rid of the shale automatically.

When high-speed electrons pass through gases they displace electrons from the atoms of the gas, and leave it in a so-called ionised state which conducts electricity, since the displaced electrons can move freely in an electric field. This property can be used industrially to conduct away troublesome electric charges. This happens, for example, in the weaving of some fabrics such as nylon. The fabric collects electric charges and thus attracts dirt and produces marks. If the air is made conducting by a radioactive source, the electric charge leaks away and marking is prevented. Static eliminators have been developed by the Shirley Institute, using radio thallium or radium strontium, incorporated into a silver foil. This property of ionising gases is also useful in helping cold-cathode valves to become conducting at a consistent voltage. A little radioactive hydrogen is introduced into the valve and then taken out again, leaving enough behind on the walls to throw out sufficient electrons to produce the requisite amount of ionisation.

PROCESS CONTROL.

Radioactive materials can be employed for a wide variety of process controls, by making use of the extremely sensitive methods available for their detection—methods which can detect as little as 10^{-12} gram. In one interesting example, a cattle-food manufacturer was adding a very small trace of a vitamin to a large amount of cattle food and it was difficult to establish if his mixing process was adequate. A small amount of radioactive sodium chloride was added to the vitamin before mixing. The food was then passed on to a conveyor belt, where a counter indicated the activity and showed directly whether the mixing was uniform.

The Chemical Engineering Division at Harwell have used radioactive tracers to control separation processes. Hafnium and zirconium occur together in nature and have to be separated to produce zirconium metal suitable for atomic piles. This can be done in an ion-exchange column. A little radioactive zirconium and hafnium is added to the material to be separated. The two materials are first adsorbed on the ion-exchange resin until the resin is saturated. At this stage, radioactivity begins to appear at the bottom of the column. A washing-out agent for one material is added and it is possible by measuring the radioactivity to measure how much of it is removed. When the greater part of this constituent has been washed out, the second washing-out agent is added and so the second material is separated.

The ease with which small amounts of material can be detected by their radioactivity makes it possible to use radioactive tracers as leak detectors. Radio sodium is dissolved as sodium carbonate in water at quite low levels of activity and inserted into a leaking water main. Measurements are then made of ground-water samples with a radiation counter. It proved to be possible to detect leaks as small as one pint per hour. Leaks in underground cells can also be detected by radioactivity. In France, a number of long-distance telephone cables contain paper-insulated wires in a jute-covered lead envelope under a pressure of 0·8 atmosphere of nitrogen. Any hole in the lead envelope would be disastrous, if not detected and repaired before water had time to leak in. The approximate position of the leak can be found by pressure-fall methods. A radioactive gas, methyl bromide with radio bromine, is then injected. The leakage can then be detected by instruments carried above ground by a man walking at a brisk pace.

RADIOACTIVE SOURCES AS MARKERS.

It is often necessary to determine the position of objects in underground borings or pipelines; thus, a 50-mile pipeline in Scotland had to be cleared before admitting oil. This was done by a scraper. If it stuck, it would be very difficult to locate the exact position, so a small source of radio cobalt was attached to the scraper, which could easily show up its position. In drilling vertical and horizontal boreholes for underground gasification work, it was desirable to measure the miss distance of the two bores; so a radio cobalt source was put in one bore and a radiation meter in the other, enabling the miss distance to be measured with an accuracy of a few inches. In a similar way, the arrival of the interface between two batches of oil in a pipeline can be determined exactly, so that the new batch of oil can be diverted to a separate tank.

RADIOACTIVE MATERIALS IN CHEMICAL ENGINEERING.

In addition to these proved applications of radioactive materials to industry, new and larger-scale applications are beginning to appear on the horizon, with the coming advent of much larger radioactive sources. The applications I have described so far have required radioactive sources having an activity at the most equivalent to that of a gram of radium. We can now produce radio cobalt or radio iridium sources having an activity 1,000 times higher—we call this a 1,000-curie source. We can also envisage, within two or three years, extracting from radioactive waste products sources of radio cæsium 100,000 times greater than one gram of radium. We are using at present a 300-curie radio cobalt source at Harwell to study the effect of radiation on chemical reactions. In these reactions, gaseous products, such as ethylene, are transformed by high temperature and pressure in the presence of a catalyst into a polymer, such as polythene. Now it is found that these reactions will take place in the presence of radiation without the high temperature. This might result in production economies. Radiations can also change the properties of the

* The 1953 Sir Alfred Herbert Paper, delivered to the Institution of Production Engineers, at Oxford, July 24, 1953. Abridged.

polymer by producing more cross-linkages in the molecule.

APPLICATIONS TO INDUSTRIAL RESEARCH.

Many applications to industrial research have been found which make use of the great sensitivity of methods of detection of radioactive elements. Messrs. Courtauld wished to determine the distribution of lubricant used in spinning nylon thread along the thread. A little radioactive methyl bromide was added to the lubricant and, after spinning, the fibre was placed over a photographic film. On development, the film was blackened in proportion to the intensity of the radioactivity, which in turn was proportional to the thickness of lubricant at that point. As little as 10^{-10} gm. of lubricant per centimetre of fibre length could be detected.

Lubrication research studies have been facilitated by making a piston ring radioactive by exposing it in a pile. The radioactive iron of the piston ring is rubbed off and appears in the lubricant and on the cylinder wall. The amount of this can easily be measured by a photographic film in the case of the cylinder wall, and by an electrical counter for the lubricant. In these studies, the wear of 10^{-7} gm could be measured. By this very sensitive method the time to obtain results is greatly reduced. Similar studies have been carried out on commercial passenger aircraft. The occurrence of excessive wear of moving parts can be detected at an early stage. This may well simplify the problem of maintenance. Factories carrying out operations on toxic products, requiring special ventilation arrangements to ensure that tolerance breathing doses are not exceeded, can make use of radioactive gases to check the dispersion of the air used for ventilation.

Industrial organisations interested in using these new tools can obtain advice from the Industrial Applications Group of the Harwell Isotope Division, who are always prepared to give advice and on occasions to make preliminary investigations of possible applications for a modest fee. This relieves the industrial organisation from the necessity of buying electronic equipment before the application is proved. We are also prepared to train industrial staff at our Isotope School, which runs four-week courses at regular intervals. This school teaches techniques and also deals with the elementary health precautions which are necessary for those using radioactive materials. These health precautions are simple and standardised, and no organisation need be deterred from using radioactive elements for "fear of the atom."

BRITISH CHEMICAL PLANT MANUFACTURERS' ASSOCIATION.—A booklet entitled "British Chemical Plant Manufacturers' Association—Services to Members" has been issued by the Association, 14, Suffolk-street, London, S.W.1. It contains a list of officers and Council and of member firms, and brief outlines of the history and organisation of the Association and the services which it can render. The booklet has been prepared for the benefit of firms inquiring about membership, and copies are obtainable gratis on application to the secretary.

AIR-SEA RESCUE FILM.—An excellent colour film demonstrating the application of "Sarah" (the search and rescue and homing system developed by the aircraft division of Ultra Electric Ltd., Western-avenue, London, W.3) to rescue operations on land and sea has recently been prepared, and was shown to shareholders of the company at their annual general meeting on July 15. The issue of "Sarah" to the Royal Air Force is already proceeding, and by the end of the year it will be in large-scale production. "Sarah" beacon equipment, comprising a radio-beacon transmitter and aerial, a speech unit, battery, and interconnecting cables, is designed to be worn on the life jacket by flying personnel. In operation, it transmits pulses which can be detected by suitable receiving equipment fitted to search aircraft, helicopters and air-sea rescue ships, and these pulses serve to direct the craft to the wrecked personnel, with an accuracy of $\pm$ 100 ft. from an altitude of 500 ft. The beacon equipment is waterproof and has been tested under water at a depth of 50 ft. It can withstand a temperature range from — 50 deg. to + 70 deg. C., an altitude of 60,000 ft., and acceleration in excess of 50 *g*. It provides a maximum range of 66 miles to a rescue aircraft at 10,000 ft., and six miles to a rescue ship with a receiver aerial 30 to 40 ft. high. The battery is adequate for a 20 hours' continuous operation.

COMPARATOR FOR TURBINE-BLADE ROOTS.

A DIAL gauge for comparing the effective thickness at the pitch line of the root serrations of aircraft gas-turbine blades with a master pattern has been developed recently by British Indicators, Limited, John Bull Works, Sutton-road, St. Albans, Hertfordshire. The comparator, which can measure to within 0·0001 in., is illustrated in Fig. 1, which shows a bank of three gauges mounted on a common base, to allow a number of serrations to be checked without the necessity for resetting. Fig. 2 is an enlarged view of the anvils and contacts, with a blade root in position. The contacts are stellited and are interchangeable, to suit various forms of serration. The pressure applied to the contacts

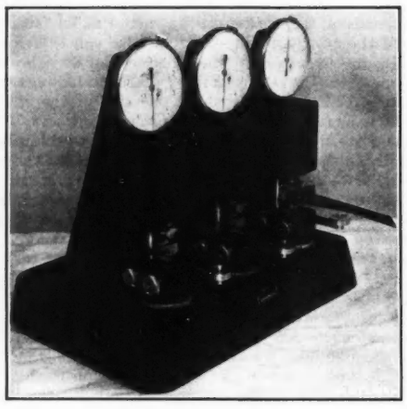


FIG. 1.

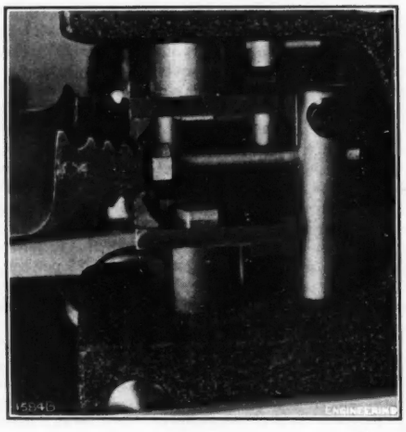


FIG. 2.

is sufficient to hold the blade firmly against its own weight, and to prevent inaccuracies arising from the leverage of the blade tip against the gauging contacts.

The lower anvil is provided with a fine adjustment by a knurled nut on the base of the instrument. The sensitive plunger carrying the upper anvil, which works in a nitrided bush to minimise wear, is controlled by a lever on the side of the instrument and operates the dial gauge through a transmission of the "follower" type, in which the sensitive plunger is held in contact with the dial-gauge plunger through a ball contact, by opposed springs.

ABANDONMENT OF NORTHERN IRELAND BRANCH RAILWAYS.—An Order has been made by the Northern Ireland Ministry of Commerce, under Section 58 of the Transport Act, authorising the Ulster Transport Authority to abandon all sections of the Belfast and County Down Railway that have been discontinued. As long ago as December 15, 1949, the Authority was authorised to discontinue all services on the County Down Railway except on the Bangor line.

S.S. "VIGILANT" FOR THE MERSEY DOCKS AND HARBOUR BOARD.

THE twin-screw steamer Vigilant, illustrated on the opposite page, has been built by John I. Thornycroft and Company, Limited, Thornycroft House, Smith-square, London, S.W.1, at their Woolston shipyard, Southampton, to the order of the Mersey Docks and Harbour Board, and replaces a former vessel of the same name, built half a century ago. She is intended for fire-fighting, the maintenance of buoys and lightships, marine survey work, and also for salvage purposes. Together with the Salvor, built in 1947, she will undertake the annual servicing of more than 100 automatically-illuminating buoys and a lightship, every three weeks. Interesting features of the new ship are the segregation into main and auxiliary engine rooms of the propelling machinery and other machinery designed to supply water for fire-fighting, and over-the-side electric current and air; and, as will be apparent from the illustration, the omission of stanchions from the main deck to the deck above, which is cantilevered out from the superstructure. With this cantilever arrangement, and also the provision of slips to all stays, it becomes possible to pass over the side a hawser, hose, cable, or air line at any point of the vessel.

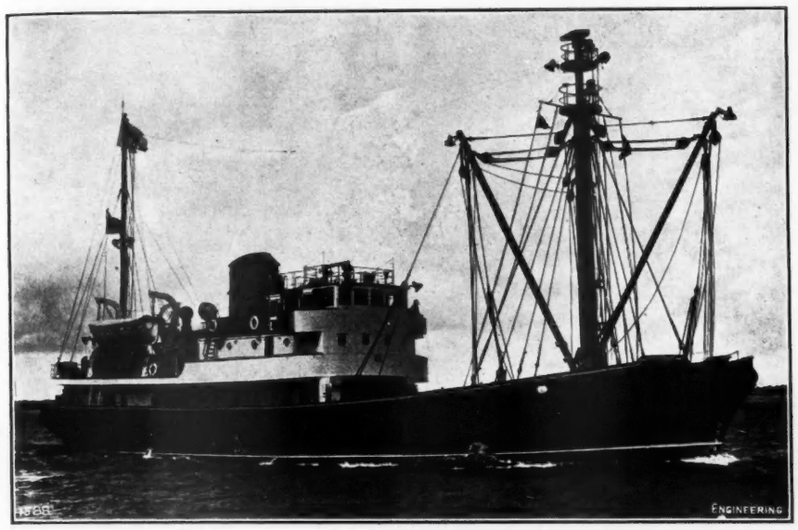
The Vigilant is built to Lloyd's Register's highest class for salvage operations. Her length overall is 172 ft. 6 in., beam 35 ft. 0 in., mean loaded draught 11 ft. 1 in., and depth from the main deck, 16 ft. 6 in. The stem is fitted with a special casting capable of supporting a load of 100 tons, and on the centre-line is an anchorage for a 100-ton purchase. A partial double bottom is provided forward of the main engine room, and is subdivided into tanks for fuel oil and fresh water. Additional fresh water is carried in the aft and forward peak tanks, and feed water for the boilers in a double-bottom tank in the main engine-room.

In the main engine-room are two triple-expansion open-type reciprocating engines, directly coupled to their respective propeller shafts. The main engines have a total indicated horse-power of 1,450 at full load, giving the vessel a speed of 12½ knots. The engines, built by Messrs. Thornycroft, are supplied with saturated steam at a working pressure of 220 lb. per square inch from two forced-draught oil-fired Scotch boilers constructed by Cammell Laird and Company, Limited, Birkenhead. All the auxiliaries associated with the propelling machinery are independently driven; they comprise two forced-draught fans, two boiler-feed pumps, one fuel-oil pumping and heating unit, bilge and fresh-water pumps. A separate motor-driven general-service pump of large capacity is also provided.

The auxiliary engine room contains the specialised equipment concerned with the services which the ship is designed to render. Power is provided by two Paxman-Ricardo Diesel engines, each with a continuous rating of 225 brake horse-power at 1,160 r.p.m., resiliently mounted and directly coupled to shunt-wound direct-current generators of the open type, manufactured by W. H. Allen, Sons and Company, Limited, Bedford. These generators are rated not to exceed a temperature rise of 72 deg. F., and to produce 180 kW at 1,160 r.p.m. Both generating sets are protected by an Aspinall alarm system for the flow of salt and fresh water, and temperature and pressure rises. The fire-fighting pump is of the two-stage type and is designed to handle up to 440 tons of sea water an hour at a pressure at the monitors of 230 lb. per square inch. The pump is directly connected to a 435-h.p. Allen direct-current motor, and feeds into a 10-in. main from which branch lines go to different points in the ship, where monitors may be connected as required. In addition to the auxiliaries to deal with cooling-water circulation, the transfer of boiler-fuel oil and Diesel oil, there are two rotary compressors and exhausters, each driven by a 65-h.p. motor. A small 35-kW Diesel set for lighting is also provided and this, like the two main generating sets, is protected by an Aspinall alarm system and fitted with a starting motor supplied with current from a bank of Exide storage batteries.

TWIN-SCREW HARBOUR VESSEL "VIGILANT."

JOHN I. THORNYCROFT AND COMPANY, LIMITED, LONDON.



Forward of the superstructure on the main deck are located one 20-ton steam winch and two 10-ton electrically-driven capstans; in addition, one 5-ton warping and cable capstan is placed forward and one electrically-driven 4-ton warping capstan on the short main deck aft. All winches and capstans have been supplied by Clarke, Chapman and Company, Limited, Gateshead-on-Tyne. For salvage work, the heavy tubular steel foremast is provided with two tubular derricks, the forward one of which is able to take loads up to 12 tons, and the other up to 10 tons.

The navigating equipment includes a radar installation supplied by Marconi International Marine Communication Company, Limited, Chelmsford, V.H.F. telephone equipment supplied by the Automatic Telephone and Electric Company Limited, Liverpool, and echo-sounding equipment supplied by Messrs. Kelvin and Hughes (Marine), Limited, London.

Immediately aft of the bridge is a chart-room, and below it is arranged single-berth accommodation for the master, chief engineer, second engineer, wreck master and steward, with a small saloon and pantry. The crew of 14, including firemen, are accommodated in two-berth cabins on the main deck, and on the same deck forward of the engine casing there is accommodation for six salvage engineers. Single cabins for a marine surveyor and two assistants are located at the forward end of the bridge deck.

NEW ELECTRICITY GRID.—The first section of the new electricity grid between Glasgow and London has now been completed and was opened by Sir John Hacking, deputy chairman (operations) of the British Electricity Authority, on July 15. This section stretches from Staythorpe, Nottinghamshire, to West Melton, near Rotherham, a distance of 42 miles. The new grid, which carries 275,000 volts, is the highest-voltage electricity supply in Britain and is intended to reinforce the existing 132,000-volt national grid.

GRADUATE COURSES IN TECHNICAL SUBJECTS AT THE UNIVERSITY OF BIRMINGHAM.—Advanced, graduate courses in chemical engineering, in industrial metallurgy and in thermodynamics and related studies in the Department of Mechanical Engineering have been established in the University of Birmingham. Each course will occupy one academic year and will lead to the award of a Diploma of Graduate Studies in Chemical Engineering, Post-Graduate Studies in Metallurgy, and Graduate Studies in Mechanical Engineering. The inclusive fee for each course is 71*l.* 1*s.*, and all three will commence on October 5. Further information and forms of application may be obtained from the Registrar, The University, Edgbaston, Birmingham, 15.

LAUNCHES AND TRIAL TRIPS.

M.S. "GRINDEFJELL."—Single-screw cargo vessel, built by John Crown and Sons, Ltd., Sunderland, to the order of the Fjell Line (Managers: Olsen and Ugelstad), Oslo, Norway, for service on the Great Lakes, Canada. Main dimensions: 250 ft. between perpendiculars by 42 ft. 6 in. by 26 ft. to upper deck; deadweight capacity, 2,750 tons on a draught of 18 ft. 3 in. Two Clark-Sulzer Diesel engines coupled to a single shaft, constructed by George Clark (1938), Ltd., Sunderland. Trial trip, June 18.

M.S. "LONGFELLOW."—Single-screw cargo vessel, built by Henry Robb, Ltd., Leith, for the Rodney Steamship Co., Ltd., London, E.C.4. Main dimensions: 335 ft. by 50 ft. by 26 ft. 6 in.; deadweight capacity, 5,500 tons on a draught of 21 ft. 10 in. Five-cylinder Sulzer oil engine developing 2,000 b.h.p. Service speed, 11 knots. Trial trips, June 22 to 26.

M.S. "THETA."—Single-screw vessel for sealing or trawling, built by James Lamont & Co., Ltd., Port Glasgow, for Christensen Canadian Enterprises, Ltd., Montreal. Main dimensions: 145 ft. by 28 ft. by 14 ft. gross tonnage, 430. Diesel engine, constructed by British Polar Engines, Ltd., Glasgow. Launch, July 1.

S.S. "SAN FERNANDO."—Single-screw oil tanker, built and engined by Cammell Laird & Co., Ltd., Birkenhead, for the Eagle Oil and Shipping Co., Ltd., London, E.C.3. Main dimensions: 530 ft. by 69 ft. 3 in. by 29 ft. 6 in.; deadweight capacity, 18,000 tons on a draught of 29 ft. 6 in.; gross tonnage, 12,500. Double-reduction geared steam turbines. Trial trip, July 9.

M.S. "CANTENAC."—Single-screw coaster, built and engined by Chantiers et Ateliers Augustin Normand, Le Havre, France, for the French Ministry of the Mercantile Marine, Paris. Main dimensions: 194 ft. 11 in. between perpendiculars by 30 ft. 6 in. by 18 ft. 4½ in.; deadweight capacity, 850 metric tons on a draught of 13 ft. 3½ in. Two gas turbines with double-reduction gearing, developing 1,200 h.p. at 220 r.p.m. Launch, July 11.

M.S. "BARON KILMARNOCK."—Single-screw oil tanker, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for H. Hogarth and Sons, Ltd., Glasgow. Main dimensions: 548 ft. overall by 71 ft. by 38 ft. 9 in.; deadweight capacity, 16,900 tons on a draught of 30 ft.; gross tonnage, 11,810. Six-cylinder two-stroke single-acting Diesel engine, developing 6,950 b.h.p. at 110 r.p.m. in service, constructed by John G. Kincaid & Co., Ltd., Greenock. Trial trip, July 14.

M.S. "SIBONGA."—Single-screw cargo vessel, with accommodation for twelve first-class passengers, built by the Nakskov Shipyard, Ltd., Nakskov, Denmark, for the East Asiatic Co., Ltd., Copenhagen. Main dimensions: 456 ft. between perpendiculars by 62 ft. 6 in. by 38 ft. 3 in. to shelter deck; deadweight capacity, 10,200 tons on a draught of about 27 ft. 1 in. First vessel of a new series for these owners. Seven-cylinder single-acting two-stroke Diesel engine, developing 8,200 b.h.p. at 115 r.p.m., constructed by Burmeister and Wain, Ltd., Copenhagen. Speed, 17 knots, fully loaded. Trial trip, July 14.

TRADE PUBLICATIONS.

Cranes.—We have received from Geo. W. King, Ltd., Hitchin, Hertfordshire, a copiously illustrated handbook describing the wide range of cranes that they make. The introduction includes notes on design, construction, operation and maintenance, and is followed by sections giving brief specifications of each model as well as of auxiliary equipment, such as grabs, hoists, gearboxes, etc.

Portable Air Compressors.—Holman Bros., Ltd., Camborne, Cornwall, have sent us a copy of the recently revised section of their catalogue dealing with portable air compressors. This catalogue gives detailed specifications of each of the primary components of the compressors as well as of the compressors themselves.

Valves and Cathode-Ray Tubes.—We have received from Ferranti, Ltd., Hollinwood, Lancashire, a handbook containing technical data of the receiving valves, cathode-ray tubes and industrial valves manufactured by them. It contains a number of useful performance curves and diagrams.

Underground Haulage Signalling System for Locomotives.—Details of the colour-light signalling system designed by them for use when two or more locomotives are operating in the same underground area of a mine are contained in a leaflet received from Automatic Telephone and Electric Co., Ltd., Liverpool.

Radar for Cargo Vessels.—The application of the Decca radar system to cargo vessels is described in a leaflet received from Decca Radar, Ltd., 1, Brixton-road, London, S.W.9.

Relay Units.—A booklet received from Standard Telephones and Cables, Ltd., Aldwych, London, W.C.2, includes descriptions of the relays designed by them for use on remote-control systems

Electronic Impulse Frequency Telemetering.—Standard Telephones and Cables, Ltd., Aldwych, London, W.C.2, have published a booklet giving details of their impulse system of telemetering, by which it is possible to transmit readings of watts, vars, volts and amperes over individual line circuits and thus to avoid the use of multi-core cables. The system embodies electronic techniques and employs miniature components, including cold cathode tubes and thermionic valves.

Grain Driers.—Particulars of the platform and silo grain driers manufactured by them in complete units and consisting of aerofoil or propeller fans and dust air heaters are given in a leaflet received from the General Electric Co., Ltd., Kingsway, London, W.C.2.

Industrial Grinders.—International Combustion, Ltd., 19, Woburn-place, London, W.C.1, have sent us a well-illustrated booklet containing descriptions of the application of the Hardinge conical mill to industrial grinding.

Usco Plate Air Heaters.—The design of Usco plate-type air heaters is described in a pamphlet received from International Combustion, Ltd., 19, Woburn-place, London, W.C.1.

Travelling-Grate Stokers.—Numerous photographs and drawings reproduced in a booklet received from International Combustion, Ltd., 19, Woburn-place, London, W.C.2, enable a good idea to be obtained of the "L" type travelling-grate stoker manufactured by them.

Photo-Electric Level Control.—A leaflet received from Radiovisor Parent Ltd., 1, Stanhope-street, London, N.W. gives details of the photo-electric equipment they manufacture for controlling the level of materials in hoppers and bunkers of all types.

Ladder and Step Equipment.—We have received from the Angel Truck Co., Ltd., Albion-road, Stoke Newington, their new Ladder and Step Catalogue No. 64, which illustrates the wide selection of ladders, steps, cradles and rising trestles which they manufacture for the building trade and general household use.

Industrial Lighting Fittings.—A well-illustrated pamphlet with the title "Lighting the Way" has been received from The Benjamin Electric, Ltd., Brantwood-road, Tottenham, London, N.17. It briefly sets out the history of the company since its formation in 1908 and gives some idea of the plant, research and technical facilities which they have available for the production of industrial lighting fittings.

Light Alloys for Structural Work.—Some interesting examples of structural work in light alloys for the building industry and in engineering and marine applications are illustrated in a leaflet published by E. C. Payter & Co., Ltd., Meeting-street, Great Bridge, Tipton, Staffordshire.

Industrial Gases.—Typical applications of oxygen, oxy-acetylene and oxy-hydrogen for cutting heavy steel plates and other large masses, for removing surface scale, and for welding and other purposes, are dealt with in a brochure entitled "All in the Day's Work," issued by the British Oxygen Co., Ltd., Bridgewater House, Cleveland-row, St. James's, London, S.W.1. The use of argon, neon, helium and other rare gases in industry, and the activities of the firm's chemical and medical divisions are also described.

HEAVY INDUSTRIAL DIESEL-ENGINED TRACTOR.

THE "AP 4" heavy industrial Diesel-engined tractor shown in the accompanying illustration has been introduced by Lansing Bagnall, Limited, Kingsclere-road, Basingstoke, as an addition to their range of electric and petrol-engined tractors. It incorporates the standard Perkins P.4 four-cylinder engine which develops 42 brake horse-power at 2,000 r.p.m. The tractor is capable of towing loads of 45 tons on a level surface. It has a wheelbase of 46½ in. and a turning radius of 140 in., which enables it to be manœuvred in confined spaces. The maximum drawbar pull is 4,500 lb. The makers state that the tractor is ideal for towing heavy trailer loads, boilers, and other heavy pieces of equipment used in the engineering industry. It will operate over rough ground and can be used for moving railway wagons or for the ground haulage of aircraft. The tractor has been approved for use on public roads and complies with the Motor Vehicles (Construction and Use) Regulation No. 670.

The engine is mounted on resilient rubber pads to reduce the shock transmitted to it when the vehicle is operating on rough ground. These mountings also keep the vibration from the engine to the chassis to a minimum. The C.A.V. governor is set for 2,000 r.p.m. The gearbox has four forward speeds and one reverse. When the engine is running at the governed speed, the ground speeds are 14·5, 8·6, 4·7 and 2·3 m.p.h., and 1·9 m.p.h. in reverse. The clutch-plate is 11 in. in diameter, and the thrust pad is of the ball-bearing type. The transmission is through a Layrub universal-type coupling, and the axial and radial displacement is taken up by resilient trunnion blocks; a Ki-gass starter is fitted. The main fuel tank has a capacity of 4 gallons and a subsidiary tank is provided for the starter. The battery is of the 12-volt heavy-duty type of 113 ampere hours capacity.

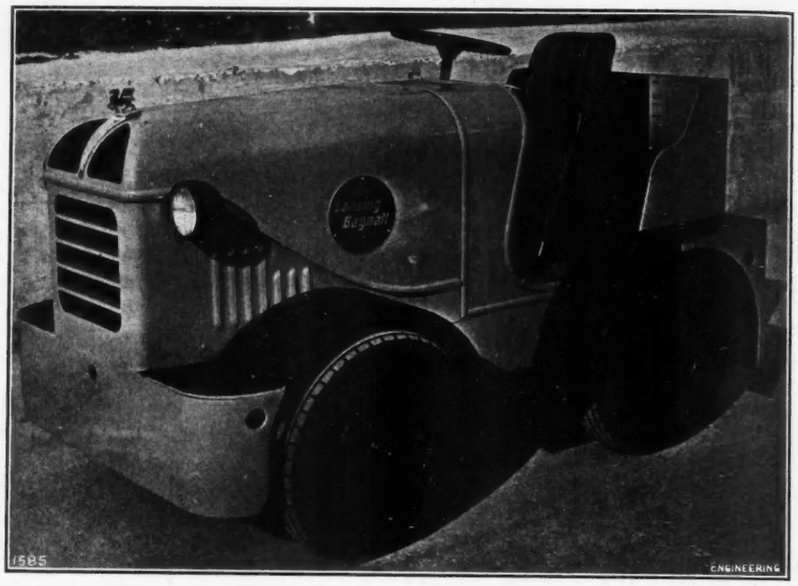
The tractor bonnet is of the alligator type, hinged at the rear end. It can be held open at 45 deg. by a pivoted stay. The driving seat is hinged and has a compartment beneath it for the battery and tools. The main frame of the tractor is fabricated from heavy sections, and holes are provided in the bumper plates for grappling hooks or slings; these plates are also made from steel of a heavy cross-section to provide good all-round protection. The wheels are of the pressed-steel type and the tyres are 23 in. by 5 in. at the front and 25 in. by 6 in. at the rear. The surfaces of the body are given a rust-resisting treatment and the exterior is sprayed with a cellulose paint. The finish colour of the vehicle is normally scarlet with black wheels, mudguards and floor plates. The overall height is 54 in. and the width 60 in. on models with twin rear wheels, and 48 in. in the case of single rear-wheel models. The overall length is 84 in. and the ground clearance is 7 in. The total service weight is 44 cwt.

REVOCATION OF COPPER-CONTROL ORDERS.—The Minister of Supply has issued an Order, the Copper, Lead and Zinc Distribution (Revocation) Order, 1953 (S.I. 1953, No. 1082), to come into operation on August 5. The effect of this Order is that when the London Metal Exchange resumes dealings in copper, next month, licences will no longer be required for the purchase of any form of copper. Import arrangements are being announced by the Board of Trade, in Notice to Importers No. 575, July 15, 1953, obtainable from the Import Licensing Branch of the Board of Trade, 43, Marsham-street, London, S.W.1.

WIND-VELOCITY SIGNAL ANEMOMETER.—Messrs. R. W. Munro, Ltd., Cline-road, Bounds Green, London, N.11, have designed an anemometer to give audible and visual warning when the wind velocity reaches a pre-determined value. It consists of a cup, which houses a contact, a lamp and an electric horn, the velocity at which the warning is given being varied by adjusting a pointer on a scale. It is intended for mounting on a mast so raised above the building or superstructure as to be in the undeflected wind-stream. The warning-light box is fitted with red and white windows, the lamp behind the former showing when the pre-set velocity has been reached and the latter that the system is in working order.

INDUSTRIAL DIESEL-ENGINED TRACTOR.

LANSING BAGNALL, LIMITED, BASINGSTOKE.



BOOKS RECEIVED.

The Fluoridation of Domestic Water Supplies in North America as a Means of Controlling Dental Caries. Report of the United Kingdom Mission, February-April, 1952. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 5*s.* net.]

Principles of Mathematical Analysis. By WALTER RUDIN. McGraw-Hill Book Company Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 5 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 40*s.*]

Industrial Wastes: Their Disposal and Treatment. Edited by WILLEM RUDOLFS. Remhold Publishing Corporation, 330, West 42nd street, New York 36, U.S.A. [Price 9.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 76*s.* net.]

Metal Industry Handbook and Directory 1953. Louis Cassier Company, Limited, Dorset House, Stamford-street, London, S.E.1. (Available only to subscribers to *Metal Industry* at a combined subscription of 52*s.* per annum.]

Cours de Mécanique. Vol. 1. *Statique.* By PROFESSOR HENRY FAVRE. Second edition. Éditions Leemann, Stockerstrasse 64, Zurich 39, Switzerland. [Price 35 Swiss francs bound, 32 Swiss francs in paper covers.]

Trusts and Foundations. A Select Guide to Organizations and Grant-making Bodies Operating in Great Britain and the Commonwealth. Compiled by GUY W. KEELING. Edited by THOMAS LANDAU. Bowes and Bowes, 1 and 2, Trinity-street, Cambridge. [Price 42*s.* net.]

Massachusetts Institute of Technology. Abstracts of Theses accepted in 1951-1952. Massachusetts Institute of Technology, Cambridge 39, Massachusetts, U.S.A. [Price 2.50 dols.]

Bautechnik-Archiv No. 7. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 9.60 D.M.]; and Lange, Maxwell and Springer, Limited, Maxwell House, 242, Marylebone-road, London, N.W.1. [Price 16*s.* 10*d.*]

The Dimensioning of Engineering Drawings. By DR. W. ABBOTT. Blackie and Son, Limited, 17, Stanhope-street, Glasgow, C.4. [Price 10*s.* 6*d.* net.]

Report of the Forest Products Research Board with the Report of the Director of Forest Products Research for the Year 1952. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3*s.* net.]

Principles of Electronics. By DR. H. BUCKINGHAM and E. M. PRICE. Cleaver-Hume Press Limited, 42a, South Audley-street, London, W.1. [Price 15*s.* net.]

Lubricant Testing. By E. G. ELLIS. Scientific Publications (Great Britain), Limited, 8, Walker-street, Wellington, Shropshire. [Price 37*s.* 6*d.* net.]

The Instrument Manual. Second edition. United Trade Press, Limited, 9, Gough-square, Fleet-street, London, E.C.4. [Price four guineas.]

Whillans's Tax Tables and Tax Reckoner, 1953-54. By GEORGE WHILLANS. Butterworth and Company (Publishers), Limited, 88, Kingsway, London, W.C.2. [Price 5*s.*, post free.]

Sixth Annual Report of the Advisory Council on Scientific Policy (1952-1953). H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6*d.* net.]

Diesel Engine Design. By T. D. WALSHAW. Second edition. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 35*s.* net.]

Welding, Brazing and Metal Cutting. Prepared under the direction of E. MOLLOY. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 15*s.* net.]

Modern Pumps. Edited by E. MOLLOY. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 21*s.* net.]

Properties of Metallic Surfaces. A Symposium organised by the Institute of Metals and held at the Royal Institution, London, on 19 November, 1952. The Institute of Metals, 4, Grosvenor-gardens, London, S.W.1. [Price 35*s.*]

Engineering College Research Council of the American Society for Engineering Education. Review of Current Research and Directory of Member Institutions, 1953. V. E. Neilly, Secretary, Engineering College Research Council, 103, Mechanical Engineering, The Pennsylvania State College, Pennsylvania, U.S.A. [Price 2.50 dols.]

Gestaltung und Berechnung von Ölkühlern. By ANDREA F. FRITZSCHE. Verlag Leemann, Stockerstrasse 64, Zurich 39, Switzerland. [Price 12 Swiss Francs.]

Publications du Laboratoire de Photoélasticité. École Polytechnique Fédérale, Zürich. No. 5. *Experimentelle und theoretische Untersuchungen an dünnen Platten.* By DR. BERNHARD GILG. Verlag Leemann, Stockerstrasse 64, Zurich 39, Switzerland. [Price 12.50 Swiss francs.]

Mitteilungen aus dem Institut für Thermodynamik und Verbrennungsmotorenbau an der eidgenössischen technischen Hochschule in Zürich. No. 11. *Wandwärme- und Liefergrad-Messungen an einem Luftkompressor.* By DR. MAHMOUD M. GHONEIM. Verlag Leemann, Stockerstrasse 64, Zurich 39, Switzerland. [Price 6.25 Swiss francs.]

Report of the Road Research Board, with the Report of the Director of Road Research for the Year 1952. H.M. Stationery Office, Kingsway, Landon, W.C.2. [Price 4*s.* 6*d.* net.]

NATIONAL COLLEGE OF HOROLOGY.—An illustrated prospectus of the National College of Horology and Instrument Technology, which is accommodated at the Northampton Polytechnic, St. John-street, London, E.C.1, has now been published. It contains particulars of the courses available and also deals with the history and aims of the College, the requirements for admission, arrangements for deferment from National Service, the scholarships and prizes available, and other matters of interest to intending students or their parents. The autumn term of the forthcoming 1953-54 session will commence on September 28. Copies of the prospectus may be obtained on application to the Head of the College at the address given above.